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DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

FOR THE YEAR 1945 VOLUME VI

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The Progress of Science

A MONTHLY NOTEBOOK COMPILED UNDER THE DIRECTION OF DAVID S. EVANS

Ambassadors of Science

It is reported that the Parliamentary and Scientific Committee are considering the question whether the Government should appoint diplomatic attachés capable of understanding problems with scientific and technical implications. This is a very welcome sign for such appointments are long overdue. Indeed, the need for such representation overseas has already been pressing enough to lead to the appointment of a number of scientific "ambassadors" in various departments of international relations although nearly all of these posts are essentially of a temporary character. For immediate war purposes international scientific collaboration between the Allies has been dictated by circumstances, and these needs have been met, both by the maintenance of scientific missions and liaison officers, and by frequent visits of individual scientists or groups of scientists between Britain, the U.S.A. and the U.S.S.R.

In addition there have been a number of exchange visits which have been rather less specifically military in character, being directed towards the revelation in one country of the scientific achievements of another. Chief among these has been the mission of Dr. Joseph Needham to China, which has given the scientific world in Britain a much better understanding of the advances and efforts being made in the vast country which first bore the weight of totalitarian attack and which, for all her size, is dangerously isolated from the rest of the United Nations. Perhaps the same may be said of India, whose scientific isolation has to some extent been broken down by the mission of Professor A. V. Hill, which was followed by the visit of a group of eminent Indian scientists to this country and America.

War is an activity which feeds on one particular class of scientific work, and for its effective prosecution a good international liaison must be maintained. The victories of peace are equally scientific: no great measure of reconstruction or of social progress can be made without a proper consideration of the technical details which permeate the whole structure and which often have a deciding influence on the economic and political aspects of such measures. While it is therefore correct that the two sorts of scientific ambassador which we already have should continue to carry on their essential functions, this division into "military" and "cultural" is not a particularly helpful one. It seems to have arisen because the appointment of these ambassadors has been an *ad hoc* measure; we do not yearn for a shiny chromium-plated organisation just for the fun of the thing, but it would be an advantage if the business could be organised in a more rational way. Probably no great changes will come about during the war, but it seems likely that in peace-time there may have to be three different sorts of scientific attaché. In the first place there would be men concerned with military problems, whose business it would be to watch the technical developments in the military sphere or, if Sir Robert Robinson's proposal for preventing German re-armament by means of nitrogen sanctions or any similar proposal is adopted, to watch the enforcement of such sanctions. In the case of Germany it may be intended that such measures should come under the control of the Armistice Commission but, even so, whoever is responsible will be in a sense one of our scientific ambassadors. After the last war a number of scientists did carry out such functions, but those appointments were soon allowed to lapse. After this war permanent appointments of this character will be needed both in the ex-enemy countries and, for purposes of liaison and co-operation, in allied countries.

The second type of attaché, merging indistinguishably into the first, would be concerned with the general application of science in industry. We in this country have suffered much through our failure to utilise all available scientific knowledge in industry. It may be that this failure is bound up with the nature of our economic organisation, but it would at least remove an excuse for ignorance if a deliberate attempt were made to follow in a general way the general progress of technology in the industries of other countries. Truly it will need a diplomat to do it; to be reasonably efficient and at the same time to

Dr. Joseph Needham, F.R.S., head of the British Council's Cultural Scientific Office in China. For the past two years he has been building up this organisation, which provides Chinese scientists with one link enabling them to keep in contact with their colleagues of the Western United Nations.

avoid an entirely new source of diplomatic friction by giving an opening for accusations of stealing trade secrets from friendly nations. This particular type of ambassador will be specially necessary if any real headway is to be made with the problem of the international cartel, which at the moment carries on such activity on its own account. It may be, as some contemporary thinkers have said, that these cartels are so powerful as to make it difficult for governments to make a firm stand against them, but to parallel their activities would at the least give a chance of a wider circulation of the technical knowledge upon which the power of the cartels ultimately depends.

Lastly it will probably be necessary to continue the kind of cultural activity now carried out by the British Council. Objection may be taken to this on the ground that the normal international channels of scientific communication will, we hope, soon be re-established. Nevertheless, the achievements of a nation in the scientific field are one of its best advertisements: they constitute, in the case of the United Nations, material suitable as propaganda for democracy. We must look ahead to a time when our sensibilities may have been blunted, and when a new generation a little bored with father's bomb stories may relax its vigilance. After the last war we neglected to go on saying that democracy is a good thing and many people in this country were not sufficiently often reminded of its goodness. They were prepared to listen when it was whispered that democracy was decadent and inefficient. We must not only become more democratic, we must say so rather insistently, both at home and abroad, and part of this will consist in saying that a country which is producing first-rate science is not decadent in one department of its national life at least. And in the reverse direction, ambassadors of this class must bridge the barriers of language and isolation and make more generally available to us here the knowledge of foreign scientific achievement, and produce among the scientific world that admiration and friendliness which good work inspires.

So much for overseas, but we need ambassadors of science here at home. We need the kind of attitude to science in public life which will lead to the appointment of these overseas ambassadors—and perhaps some of them ought to be ambassadors in fact and not merely attachés. We need to cure the kind of myopia which allowed the Parliamentary Science Committee, forerunner of the Parliamentary and Scientific Committee, to lapse at the beginning of the war. We need to combat the very prevalent attitude in the universities which finds science unwelcome and cannot find a place in academic activity for what it regards as "stinks", tinkering, or garage-hand work—in a word it regards science as no fit activity for a gentleman. Finally we need to persuade such bodies as the Trade Union Congress, which so far has found no work for its scientific advisory committee to do, that science is not exclusively a genteel activity, and that a broad view of their own functions in respect of working conditions and the organisation of industry as a whole would bring within their ambit a vast number of scientific problems.

The scientists who take on these tasks will need not only technical ability but half-a-dozen other skills as well. Probably the most difficult task will be to get scientists of the necessary calibre to undertake them. Professor A. V. Hill is laboratory-sick and will not stand for Parliament at the next election. He has earned the right to go back to his research, but who will replace him in Parliament and who will be available to undertake these other ambassadorial functions? The solution would seem to lie in the direction of temporary appointments, which would be short enough to prevent their holders from ceasing to be scientists. There may be difficulty in recruiting from industry men whose loyalty may be to their own industry and who look to it for re-employment: recruitment from the universities may, on the other hand, not get the kind of industrial experience necessary for at least part of the work. But these difficulties belong to a later stage. The first barriers remain to be crossed.

Diabetes and Alloxan

DIABETES is an example of a disease for which a satisfactory treatment is known although its ultimate cause is still obscure. The immediate cause is known to be the failure of the pancreas to secrete adequate quantities of insulin. Lack of this hormone results in the body being unable to utilise sugars properly. (The latter may be taken into the body as such or result from the metabolism of carbodrates.)

As long ago as 1889 it was shown by Van Mering and Minkowski that all the symptoms of diabetes can be produced in animals by removing the pancreas. Later it was demonstrated that insulin was produced only by certain cells of the pancreas which formed the so-called "islets of Langerhans". In 1922 F. G. Banting and C.

H. Best succeeded in extracting insulin from the pancreases of freshly-slaughtered cattle. To-day such extracts are used all over the world for the treatment of diabetes, and by their use the lives of diabetic patients can be indefinitely prolonged and they are enabled to carry out almost all ordinary occupations.

Although the present form of treatment produces satisfactory results it is not without its disadvantages. It requires the patient to suffer the discomfort of daily injections throughout life. Secondly, an excess of insulin can cause symptoms almost as serious as those due to deficiency, so it is necessary to plan the dosage with great accuracy. There is thus a real need for information about the fundamental cause of the disease. When this is known it may become possible to devise treatment which will effect, in some cases at least, a permanent cure and eliminate the need for treatment on a day-to-day basis as at present.

Recent research has brought to light important new facts about the disease. It has been found that all the symptoms of simple diabetes can be produced in rats and rabbits by the injection of a substance known as alloxan. This compound is closely related, chemically, to uric acid, which is a normal constituent of urine. Twenty-four hours after injection of alloxan—at the rate of 200-300 milligram per kilogram of body-weight—the animals pass into a typical coma. This diabetic condition can be controlled by means of insulin. Microscopic examination of the tissues after death shows that of all the tissues in the body visible changes occur only in the islets of Langerhans, and in certain cells of the kidney. The effect on kidney cells has been known for some years, and indeed it was while investigating this phenomenon that the diabetic effect was recently discovered.

The full significance of these results must await further study, but it is obvious that they have opened a completely new field of research. From the point of view of laboratory investigation the work apparently provides a simple method of producing the symptoms of diabetes in animals. Formerly this could be done only by removing the pancreas, an operation which precluded the observation of further changes in that organ. Of more general interest is the possible part played by alloxan in the origin of diabetes. If diabetes can be caused experimentally by deliberately injecting alloxan into the body, it is clearly possible that the disease may arise spontaneously from the production of alloxan by the body itself. While this hypothesis is by no means proved there are a number of facts to support it.

The close chemical relationship between alloxan and uric acid has already been mentioned. Alloxan is, in fact, an oxidation product of the latter. Uric acid itself is the normal end-product of the metabolism of purines, which are substances derived from the proteins present in the nuclei of cells. Some inborn error of metabolism within the body might well result, over a period of years, in the production of enough alloxan to bring about damage to the islets of Langerhans sufficient to cause diabetes. Alloxan has been isolated from animal secretions. As long ago as 1862 Liebig obtained it from a specimen of mucus which he collected from a case of what he describes as "intestinal catarrh". The mucoproteins, which are proteins found in mucus, have recently been shown to be of greater physiological importance than was formerly supposed; they have, for example, been related to diseases of joints and to the grouping of blood.

The general properties of alloxan already described have now been amply confirmed in a number of laboratories. There is, however, some difference of opinion concerning the meaning of a curious effect noted immediately after injecting the drug. This first effect is similar to the one that follows an injection of insulin—namely a rapid fall in the sugar content of the blood. This is followed very quickly by a rapid increase in blood-sugar giving rise to the diabetic condition described. Two explanations have been put forward to account for the curious initial decrease. According to the first, the alloxan stimulates the islet cells to produce insulin and they die as a result of over-activity. Alternatively, and perhaps rather more probably, it is supposed that as the cells die their insulin is liberated into the blood. Certainly the known insulin-content of the normal pancreas would be sufficient, if quickly released, to account for the initial fall in blood sugar. Whichever explanation proves correct the general importance of the work will not be affected.

Looking for Cracks

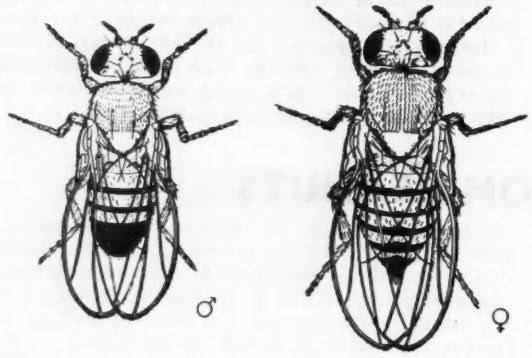
ONE familiar way of looking for cracks is by the aid of the ear. We flick a glass with our finger nail and the clear bell-like sound tells us that all parts of the glass are vibrating together and that it is therefore uncracked. The same can be done with some metallic objects; the traditional method of testing the wheels of railway coaches is to tap them with a hammer.

However, for large parts the method is obviously unsuitable and, what is more, it only gives a sort of "all-over" test and does not reveal the presence of very minute cracks. The minute cracks are of great importance, especially in high-speed machinery which has to withstand great stresses in working, because these small cracks rapidly develop into fissures which weaken the structure and which may lead to failure of the part. Such cracks are of various kinds. Some of them arise during the manufacture; for example, an ingot or billet may have a bubble in it or, what is just as bad, there may be a pocket of slag inside. When the metal is forged or rolled or drawn this bubble may be stretched out and result in a thin crack running all the way down a rod.

Again, in tempering processes, the metal may be heated and then plunged into oil or water to produce a hardened skin. The rapid changes of temperature which are necessary for case-hardening are, of course, accompanied by expansion and contraction of the metal. The rapid cooling may result in the production of internal strains in the metal great enough to produce small fractures or cracks. These may at first lie deep in the metal, but in use they may spread and become dangerous.

Yet another type of crack can start from an irregularity in the metal surface. Sudden changes in the section of a part, as for example a wheel boss pressed on to an axle, are favourite places for cracks to start; in this instance they originate at the angle between the boss and the disc of the wheel, and may spread. This type of trouble was encountered many years ago, but in recent years with the

This Fly has its Own Journal



It is perhaps no exaggeration to say that we have learned more about the laws of heredity from the study of one single species of fly than from the whole of the work done on all other organisms. There is no doubt that some of the greatest achievements in modern genetics and cytology have come from the investigation of the small fruit flies known as *Drosophila*. These flies are quite common wild in this country, and can often be caught in larders to which they are attracted by the smell of stored apples and pears. Frequently they are to be seen crawling over the windows of buses and trains. The male (*left*) and female flies are pictured above.

It was in 1901 that two American investigators, C. M. Woodworth and W. E. Castle, looking for a suitable animal for experimental breeding studies, decided to "domesticate" *Drosophila* and use it for studying in-breeding and selection. It has since proved so useful for these purposes that it is being bred in about a hundred research laboratories scattered over five continents.

What advantages has *Drosophila* to offer over other organisms? Catching the flies is a simple matter; all that has to be done is lay "fruity" traps beneath the trees of small woodlands, and the insects are guided to the bait by their sense of smell. Contained in glass tubes together with a small quantity of food, the grubs of *Drosophila* can be conveniently sent through the post. It has a very rapid reproduction rate, requiring from ten to twenty days for one generation. This is well illustrated by the strain called *Oregon-inbred* which has been kept going for four years by brother-sister matings; this is equivalent to two thousand years of inbreeding in man.

The flies can be conveniently cultured in phials placed in a thermostatically-controlled incubator, reserve stocks being kept in milk bottles on the laboratory shelves. It is customary to feed *Drosophila* on a jelly containing treacle and cornmeal.

Several mutants were discovered by Morgan in 1910 and he was able to demonstrate that the factor for white eyes was linked with sex. During the next few years Morgan obtained results which were best interpreted on the hypothesis that the homologous chromosomes of *Drosophila* exchange materials at meiosis (the reducing chromosome division). In 1913 A. H. Sturtevant was able to construct the first chromosome map working from the supposition that genes are linearly arranged along the chromosomes. Three years later C. B. Bridges, working in the Zoological Laboratory of Columbia University, was able to demonstrate completely the truth of the chromosome theory of heredity. Even at that late date this theory was regarded with suspicion by some biologists. Proof that chromosomes are the carriers of genes is to be ranked as one of the most important advances in the history of twentieth-century biology.

Male and female fruit flies are readily differentiated. It so happens that occasionally in cultures flies appear which have markings showing that their bodies are partly male and partly female. Morgan and Bridges studied these "twilight" flies and showed that this condition is connected with irregularities in the distribution of the sex chromosome. This led to an intensive study of inter-sexes, one of the most interesting aspects of living organisms.

Most breeding experiments depend on statistical analysis of results. Here *Drosophila* has proved to be *la bête par excellence*, for a worker setting up twenty cultures may a fortnight later have something like 2000 figures to juggle with! Galton and Pearson had at first used statistical analyses in attempts to discredit the Mendelian interpretation of heredity but thanks largely due to experiments with *Drosophila* these analyses gradually were appreciated as valuable working tools of geneticists.

One of the most striking recent developments in cytology has been the discovery by E. Heitz and H. Bauer, in 1933, that the giant structures in the nuclei of the salivary glands of two-winged flies are the chromosomes. Recently irradiation of *Drosophila* with X-rays has been a particularly fertile source of inquiry following the discovery of the salivary gland chromosomes.

By 1934 it was apparent that the ever-growing literature on *Drosophila* made it imperative that research workers should have a journal devoted entirly to information about the fly. Hence in that year the first number of *Drosophila Information Service* appeared under the joint editorship of C. B. Bridges and M. Demerec and sponsored by the Carnegie Institute of Washington. Recently the Carnegie Institute has paid homage to *Drosophila* by issuing a 250-page volume entitled *The Mutants of Drosophila melanogaster*, in which C. B. Bridges and K. Brehme describe all the known mutants of this important little insect.

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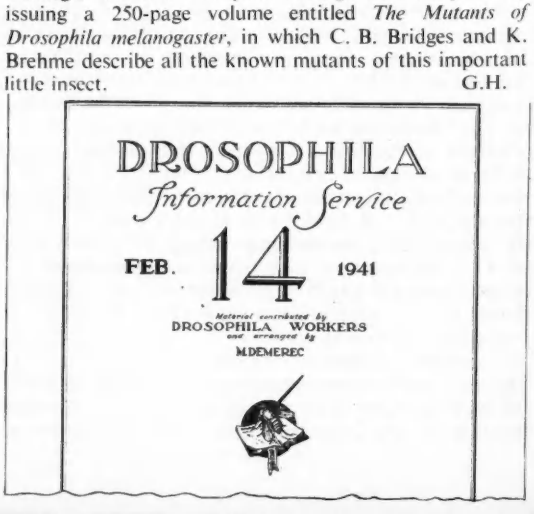
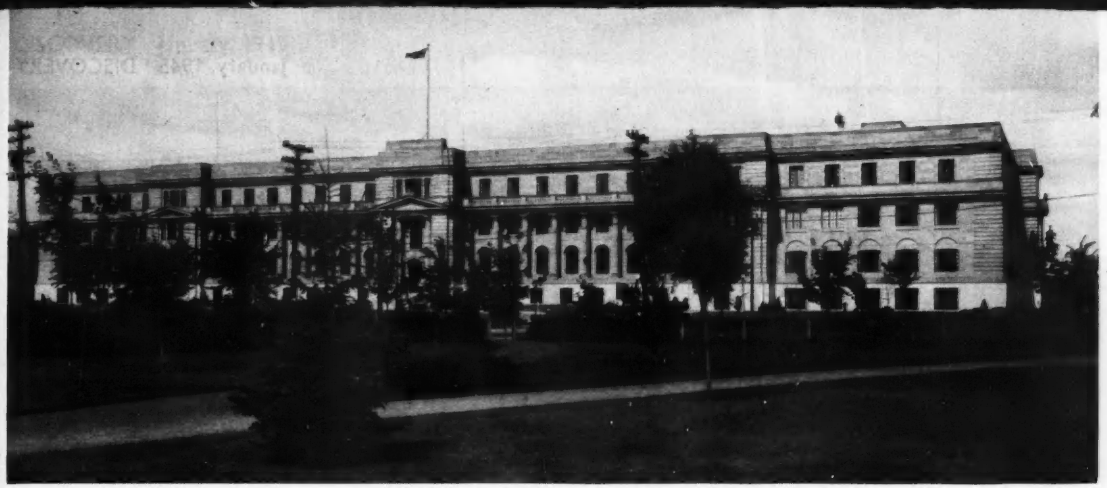




The main laboratory of the National Research Council, Ottawa

A Survey of Science in Canada

J. K. ROBERTSON, F.R.S.C.

PRESIDENT OF THE ROYAL SOCIETY OF CANADA

In 1882 the Principal of McGill University, Sir William Dawson, in giving his presidential address at the time of the first annual meeting of the Royal Society of Canada, made this statement: "Our men of science are so few and our country so extensive that it is difficult to find in any one place, or within reasonable distance of each other, half a dozen active workers in science."

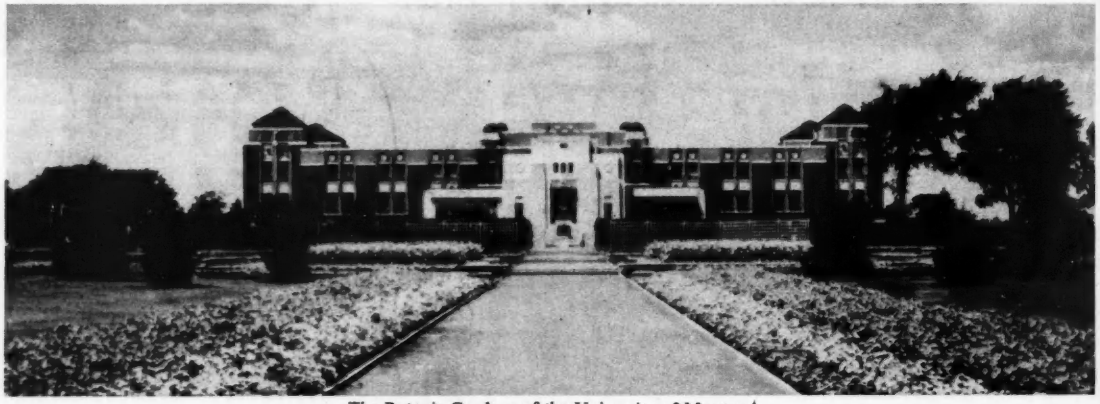
On the same occasion, T. S. Hunt, first president of Section III of the newly formed society, had this to say: "Science and letters find but few votaries in a country like this, where the best energies of its thinkers are necessarily directed to devising means of subduing the wilderness, opening ways of communication, improving agriculture, building up industries and establishing upon a proper basis schools in which the youth of the country may be instructed in those arts and professions which are among the first needs of civilized society. The teachers under such conditions can do little more than interpret to their pupils so much of the wisdom of the past, and of contemporary science, as may suffice for the immediate wants of the country, and will have but scanty leisure for original investigation in the field of knowledge."

These two quotations very aptly express the difficulties which, fifteen years after confederation, the intellectual men of Canada had to overcome before many solid contributions in the field of science could be expected. In a sparsely populated country with an area greater than that of continental Europe, and her east and west borders separated by 3000 miles of land (which in 1882 was largely undeveloped and not yet connected by rail), conditions were far from favourable for scientific research. And yet the one essential ingredient for its future development was not lacking. When in 1881 the Marquis of Lorne, Governor-General of Canada, suggested the formation of a Canadian Royal Society, he was able to gather together a group of men with vision, determination and ability.

Although the new society did not confine its attention to scientific subjects, the year 1882, when the first regular meeting was held, may well be considered an important landmark in the development of Canadian science. Without some background of scientific achievement, however, no such society could have been organized, and this article would not be complete without a reference to the period which preceded 1882.

Pioneer Days

Among the settlers and explorers in French Canada, there were naturally a few who had the necessary education and scientific curiosity to make observations of value about the fauna and flora of the young country. An outstanding example is found in Dr. Michel Sarrazin, a *médecin du roi* of Quebec, who did work of real scientific value at the end of the seventeenth and the beginning of the eighteenth century. In 1699 Sarrazin, who was a disciple of the celebrated French botanist Tournefort, was made a corresponding member of the Académie Royale des Sciences. He was co-author with S. Vaillant, a French botanist, of a remarkable manuscript, *Histoire des plantes de Canada*, now in the possession of the Seminary at St. Hyacinthe, Quebec; wrote articles on the Canadian beaver and the anatomy of the muskrat; and in botany did such important work that his name is commemorated in the *Sarraceniaceae*, and *Sarracenia purpurea*, the American pitcher plant.



The Botanic Gardens of the University of Montreal

A group of plants, the genus *Gaultheria*, calls to mind another important pioneer, Dr. Jean-François Gaulthier, who assisted the French scientist, du Monceau, in investigations on the influence of temperature on plant growth, and towards the middle of the eighteenth century sent yearly reports on this subject to the French Academy.

The early days of the British régime in Canada were not marked by any conspicuous progress in science, although in this period also data were gradually being accumulated. In 1768, for example, Andrew Graham, governor of one of the posts of the Hudson Bay Company, sent a collection of birds to the Royal Society of London, and in 1772 and 1773 J. R. Forster published articles dealing with animals and fishes of Hudson Bay in the *Philosophical Transactions of the Royal Society*.

Early in the nineteenth century, there were signs of increased activity. Work of some importance in zoology was one result of the era of Arctic exploration which centred around attempts to make the North-West Passage. For example, Dr. (afterwards Sir) John Richardson, who was surgeon and naturalist on Franklin's overland journeys in 1819-1822 and 1825-1826, published results of his observations in the appendix to Franklin's *Narrative* (1832) and in the four of volumes *Fauna Boreali-Americana* (1829-1837).

In geology, also, this period saw some of the earliest contributions, made for the most part by British Army and Navy officers. Notable among these was Dr. John J. Bigsby, who for a time served in Canada when secretary of the Boundary Commission under the Treaty of Ghent. According to the late F. D. Adams, of McGill University, Bigsby, whose investigations between 1820 and 1864, "extended from Quebec on the east to the country beyond Lake Superior in the west," is responsible for many papers dealing with the geology of North America. Bigsby also made contributions in mineralogy, publishing in 1824 an account of studies in this field.

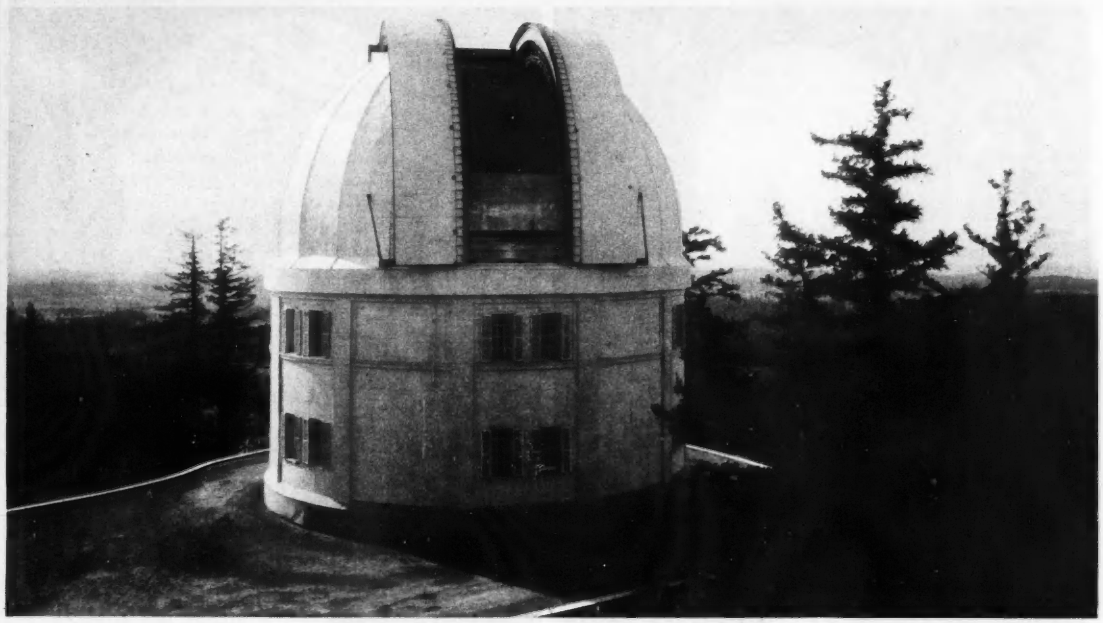
It is significant that some of the early geological observations were published in the *Transactions of the Literary and Historical Society of Quebec*, an organisation established by Royal Charter in 1824. The existence of such societies as this, which included persons interested in geology and natural history as well as in literary subjects, and of the Natural History Society of Montreal, founded in 1827, provides ample evidence that conditions favourable for the pursuit of knowledge for its own sake were gradually developing in the young country.

Beginning of the Modern Period

In the early forties of the nineteenth century events of far-reaching scientific importance occurred in Canada. In 1842 the Government made a grant for the establishment of a Geological Survey, with W. E. Logan as its first head. Logan was a Canadian who, after a number of years in business in England, did such important work concerning the geology of Welsh coal-fields that in 1837 he was made a Fellow of the Geological Society. His appointment seems to have been an exceptionally wise one, for from its outset the Geological Survey proved to be a major factor in the scientific development of Canada. Among its early achievements was the discovery and preliminary mapping of the Canadian Shield, "one of the classical areas in the world for the study of the Archean and pre-Cambrian rocks". When in 1869 Logan retired from the direction of the Geological Survey, his work was marked by two important publications. The first was a volume of nearly one thousand pages, *Geology of Canada*, which contained practically all the known geology and mineralogy of the country up to 1863; and the second was a large geological map of Canada, said to be one of the finest of its kind in the world.

Geology of Canada was written in collaboration with T. S. Hunt, who, a few years after its formation, had joined the staff of the Geological Survey as chemist and mineralogist. Hunt was a young American who had been an assistant of Benjamin Silliman at Yale, and who eventually became one of Canada's outstanding pioneers of science. He became a professor at McGill University, an F.R.S., and a president of the Royal Society of Canada. According to the late Professor Lash Miller, a distinguished physical chemist for many years on the staff of the University of Toronto, Hunt was one of the two men who "brought chemistry to Canada". The second man was H. H. Croft, who in 1843 was appointed Professor of Experimental Philosophy and Chemistry at King's College, Toronto.

Croft's appointment coincided with the beginning of active teaching in such universities as Toronto, McGill and



A view of the Dominion Astrophysical Observatory, Victoria, B.C.

Queen's, an event which is the second reason why the early forties were so important. In governmental scientific departments and in universities staffed with men qualified to teach scientific subjects and to arouse scientific curiosity, we have the two outstanding factors in the development of science, and in Canada, as elsewhere, they have been of major importance.

In the universities, the foundations for later scientific research work were slowly but steadily laid. In 1853 H. Y. Hind was made Professor of Chemistry and Geology at Trinity University (now a part of the University of Toronto), a post which he held until 1864. Hind was an active geologist who did important work in 1857 and 1858 in the little known Western Canada, and in New Brunswick in 1864, and who in 1869-71 made an official examination of the gold mines of Nova Scotia.

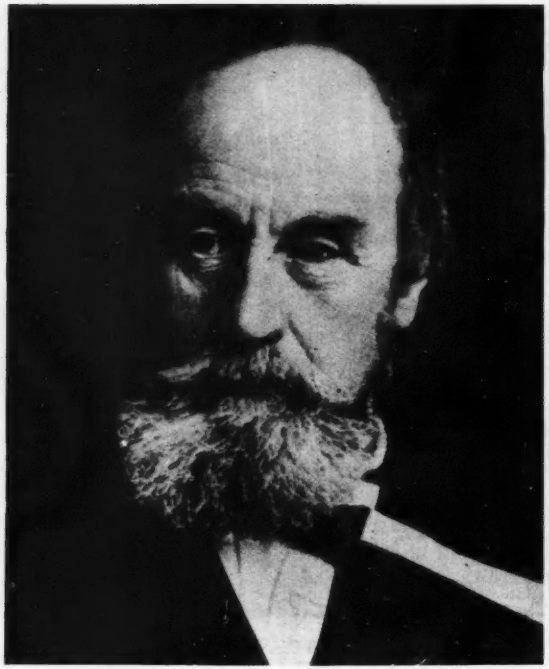
In 1853 E. J. Chapman began a period of over 30 years as Professor of Mineralogy at Toronto, a period during which he published (1864) the first Canadian text-book on geology. In 1854 an academic event of significance took place, again at Toronto, when Croft's duties were restricted to chemistry, and the Rev. William Hincks became Professor of Natural History. It speaks well for the scientific reputation of Canada at this time that a rival applicant for the post given to Hincks was T. H. Huxley.

During this same period important changes were taking place at McGill University. In 1855 W. J. Dawson was appointed Principal of the University and Professor of Geology and Palæontology, a chair which, it is worth noting, was endowed by Logan, the first director of the Geological Survey. Dawson, like Logan, was a Canadian who, after studying at Edinburgh, returned to his native land, where in later years he was made Superintendent of Education in Nova Scotia, a position which in that province is still considered to be at the top of the ladder. But Dawson was an active scientist and his educational appointment did not prevent him from continuing his geological studies of the maritime provinces, the results of which were ultimately embodied in his *Acadian Geology*. It is worth noting that some of his geological work was done in association with Sir Charles Lyell, who was his friend and a strong influence in his life.

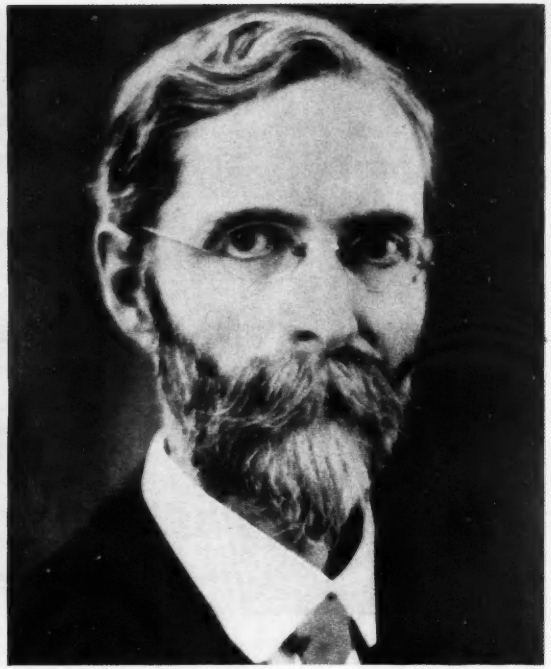
Dawson also made important contributions in botany, both in regard to living flora and to fossils, his work in the latter field forming the background for subsequent studies in plant morphology. His discovery of *Psilophyton* of Gaspé, one of the most primitive of vascular plants, did not at first receive the attention it deserved but years later its value was demonstrated by investigators of the related vascular plants from the Rhynie beds of Scotland.

During this mid-century period another important factor favourable to the development of science was the formation of scientific organisations and journals. For example, in 1849 the Canadian Institute (now the Royal Canadian Institute) was organized, and three years later it had a medium of publication, *The Canadian Journal*. It is interesting to note that among the early presidents of this society were Croft and Hincks, and that Croft was the first president of the Entomological Society, organised in 1863, a year after the foundation of the Nova Scotia Institute of Science. Other scientific journals founded at this time included the *Canadian Naturalist* in 1856, the *Journal of the Nova Scotia Institute* in 1863, *Le Naturaliste Canadien* in 1868, and the *Canadian Entomologist* in 1869.

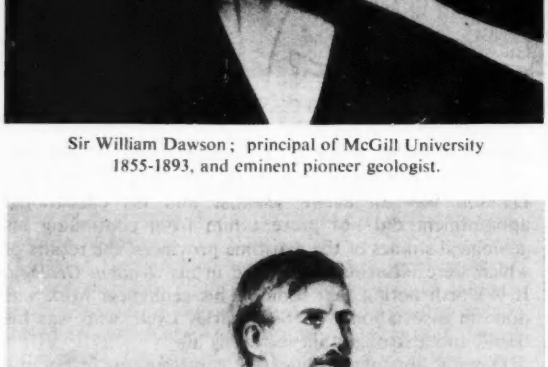
Le Naturaliste Canadien, the French-Canadian journal, still in existence, was founded by Abbé Léon Provancher,



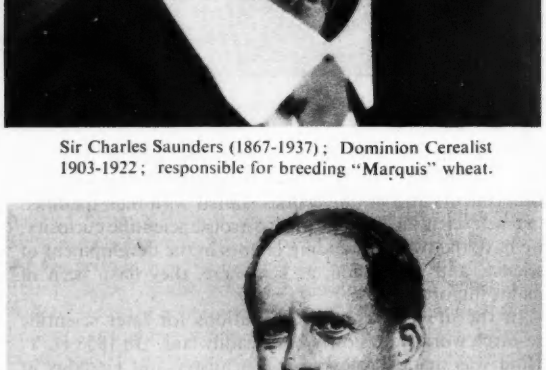
Sir William Dawson; principal of McGill University 1855-1893, and eminent pioneer geologist.



Sir Charles Saunders (1867-1937); Dominion Cerealist 1903-1922; responsible for breeding "Marquis" wheat.



A sketch of Lord Rutherford, as he appeared when at McGill University, Montreal.



Professor J. J. R. MacLeod (1876-1935); Professor of Physiology at Toronto, and Nobel Prize-winner.

and is evidence of the important work in botany which French-Canadians began in the mid-nineteenth century and have continued to the present day.

In any country the development of science is conditioned to a considerable extent by economic problems peculiar to the country, and in this respect Canada has been no exception. It was inevitable, for example, that in pioneer days investigations in geology should predominate in a country rich in minerals and with a terrain as large and as varied as that of Canada. Another example of economic influence, this time in the field of natural history, occurred in 1856 when the Bureau of Agriculture for Upper and Lower Canada offered prizes "for the best essays, respectively, on the origin, nature and habits—and the history of the progress from time to time—and the cause of the progress —of the weevil, Hessian fly midge, and such other insects as have made ravages on the wheat crop in Canada, and in such diseases as the wheat crops have been subjected to, and on the best means of evading or guarding against them". How much actual fundamental research was embodied in the essays submitted is problematical, but it is highly significant that in later years many important Canadian contributions in science had to do with wheat.

Astronomy and Meteorology

In the more physical sciences, progress before 1882 was less marked than in geology and natural history. In astronomy, following the erection by the Imperial authorities of the first observatory in Canada at Toronto in 1839, other small observatories gradually made their appearance. For example, in 1851 one was built in New Brunswick, and in 1854 another was erected within the citadel at Quebec, on the advice of Airy, the Astronomer Royal, primarily for supplying mariners with accurate time. As in other scientific fields, in astronomy there seems to have been a fair amount of amateur enthusiasm, for we read of citizens of Kingston, Ontario, acquiring in 1854 a 6¼ in. refractor to observe an annular eclipse of the sun, and of the formation in Toronto in 1868 of the Royal Astronomical Society.

In meteorology the earliest records were begun at McGill University in 1862, and pioneer observations were made at the Toronto observatory at an early date. Probably 1871 can be taken as the real beginning in that branch of science, because in that year the Canadian Government made a grant of $5000 for meteorological research. Two years later daily weather charts were begun and in 1876, for the first time, forecasts were published in Toronto papers.

In chemistry, apart from the consolidation of this subject in the universities and the work done in the laboratory of the Geological Survey, the erection of certain factories, such as acid works in 1869 to make superphosphate from phosphate rock, and plants for the manufacture of paper from Canadian wood, pointed dimly to a future in which the trappings of civilisation would be altered by chemical control of raw materials.

Since laboratory instruction in physics did not begin in England until the seventies, it is perhaps not surprising that in this subject there is little of outstanding importance to record from Canada before 1882. Reference, however, should be made to the work of J. G. Macgregor, one of the first Canadians to be elected an F.R.S., who taught physics at Dalhousie University, Halifax, first as lecturer in 1876-77, and then, following 1879, for a period of 22 years. The fact that he then succeeded P. G. Tait in Edinburgh gives some indication of his calibre.

After 1882

Although the formation of Canada's Royal Society in 1882 did not bring about any revolutionary changes, it came at a time when condition were becoming more favourable to the development of science. In 1883 a government grant of $5000 for publication of its transactions—an amount exceeding the present annual federal grant—is ample evidence that it had the support of Parliament. Numerous annual reports to the Society from associated local literary and scientific societies show that it was backed by an intelligent public opinion. In those early days, as now, the chief value of the Society lay in the bringing together of men in all branches of science to interchange ideas and to speak with a common voice on all scientific matters of national importance. In the first years of its existence we read of petitions presented to Parliament regarding the desirability of making systematic tidal observations, of appeals sent to Hudson Bay officials urging the collection of scientific data, and of a committee appointed to examine the means employed in the universities of other countries to enable young men of promise to do advanced study and research. It is significant that the report on this question included a reference to nine fellowships of $500 available to graduates of the University of Toronto for tutorial assistance and advanced study.

The next phase, at the end of which Canada had reached scientific manhood, was the outcome of three factors: the influence of the Royal Society of Canada in thus being able to speak for science as a whole, the growth of research in the universities, and the work of scientists attached to a steadily increasing number of both federal and provincial scientific departments. The story of this phase can probably best be told by dealing with individuals and individual subjects.

Geology and Mineralogy

Reference has already been made to the early work on Precambrian rocks, some of which, according to Sir William Dawson, was "well in advance of anything in Europe at that time". It was inevitable that the Precambrian should be one of two main fields in which Canadian geologists have worked and continue to work at the present time. The other field is concerned with the Pleistocene, or glacial, theory that at one time extensive ice-sheets moved across large portions of Canada, sometimes carrying large boulders of Precambrian rocks uphill for many miles. Year after year geologists from the Geological Survey, from provincial departments of mines, and from university staffs went afield collecting information —eventually covering all parts of Canada—which extended and altered fundamental theories of stratification and of glaciation, and which was at the same time of great economic importance. In a brief survey but a few of the host of

workers can be mentioned. After the pioneer work in palæontology of Sir William Dawson, Billings and others, men like G. M. Dawson (son of Sir William and third Director of the Geological Survey), Tyrell, McConnell, and Dowling, made extensive explorations in the west and north, adding greatly to our knowledge of the Canadian Rocky Mountains and obtaining valuable information relating to geological theories.

The foremost Pleistocene geologist in Canada was probably Coleman, whose studies of glaciation took him all over the world, and whose early work profoundly altered conceptions of Precambrian stratigraphy prevailing at the end of the nineteenth century. Coleman is an excellent example of the co-operation in science which has always existed between universities and government departments in Canada. He was at a once university professor and geologist and mineralogist for the Ontario Bureau of Mines, presenting in 1894 a report on the nickel of Sudbury which is considered a classic of its kind.

Brock made explorations of Northern Ontario and Hudson Bay which "laid the foundations for his broad knowledge of Precambrian geology of the Canadian Shield". Following a period on the staff of Queen's University, where he and his friend and predecessor, Miller, made the School of Mining an outstanding institution, in 1907 Brock was made Director of the Geological Survey at a time when an important reorganisation took place. Collins was another outstanding Director who devoted his chief attention to the study of the Precambrian formations of Northern Ontario. Outstanding work in stratigraphic palæontology was done by Parks, an F.R.S. who as Director of the Royal Ontario Museum of Palæontology in Toronto rendered a great national service.

By the death in 1942 of Adams of McGill University, Canada lost a brilliant geologist whose work in the physico-chemical aspects of Precambrian rocks links him with such charter members of the Canadian Royal Society as Hoffman, Harrington, Chapman and Hunt, who were both mineralogists and chemists. As early as 1883 Adams was assisting Hoffman in the laboratory of the Geological Survey in making chemical analyses of lignites, coals and ores. This early activity of the Survey reminds one of comparatively recent chemical work by such men as Ellsworth, Parsons, and Walker on pegmatite minerals, by means of which "we now know the relative succession in the earth's crusts of some rock masses, quite apart from the order of formation as is done on palæontological evidence by geologists"

Canada's Museums

In a country as rich in minerals as Canada, there were many collectors of specimens, although few were as enthusiastic as Nicol of Queen's University, and gradually museums of value came into being. There are now important collections at the various universities, at the Royal Ontario Museum of Mineralogy, and at the National Museum (in Ottawa) in which the material of the Geological Survey is incorporated. National museums in Canada, however, relating both to minerals and to natural history, do not yet occupy the position their importance justifies, and it is hoped that recommendations for a greatly improved set-up, made in 1938 by the Royal Society of Canada, will be implemented in the post-war period of reconstruction.

The work of Canadian geologists and mineralogists is a fine combination of fundamental and applied science. The palæobotanical studies of William Dawson—continued to the present day by such workers as Bell of the Geological Survey—have been of value to scientific stratigraphy and as an aid in the mapping of coal-bearing formations. Stratigraphic data have given invaluable information about the location of coal-bearing strata, gas and oil fields, and conversely the economic need for such products has stimulated more precise geological investigations. Indeed, the whole history of the growth of mining in the Dominion is intimately connected with the explorations and investigations in geology and mineralogy.

Botany and Zoology

In the field of natural history, as in geology, fundamental scientific work went hand in hand with the solution of practical problems. In 1882 a National Herbarium was begun with the purchase of a large collection of plants belonging to Macoun, a charter member of the Royal Society who was Canada's greatest exploring botanist. In passing it may be noted that Macoun, after his appointment in 1897 as Dominion Horticulturist, extended earlier work on breeding for the improvement of fruits. Of the various other herbaria which have been set up, special mention should be made of the collection at the University of Montreal and of the work of Marie-Victorin, the French-Canadian, to whom the recently-established Botanic Gardens at Montreal will always be a well-deserved monument.

In morphology the early work of Penhallow of McGill was associated with the fossil studies of Sir William Dawson. Penhallow's work, however, was by no means restricted to palæobotany, for in later years he investigated the mechanism of the plant movements. In this field, Lloyd, one of his successors at McGill, by his discovery of the trap mechanism in *Utricularia* (the bladder wort) and his general work on carnivorous plants became widely known. In mycology important fundamental work was done by Buller and his associates in Winnipeg, and by Faull, Jackson and coworkers at Toronto. In plant physiology, reference should be made to the work of Duff, Krotkov and others on respiration and its relation to ageing and disease.

On the economic side, the most outstanding contributions in botany are associated with agriculture, and of these first place should probably be given to the work of the Saunders. In 1886 the Federal Government made provision for a Central Experimental Farm (at Ottawa) and four branch farms, with William Saunders as director. Saunders was another charter member of the Royal Society, who before this appointment had been doing breeding work for the improvement of fruits and flowers. A transfer to the study of cross-breeding in cereals was a natural step and led to the production by Saunders, aided by a son Percy and by the more famous son Charles (later Sir Charles), of wheat more suitable to Canadian conditions. Such varieties as early ripening "Garnet" and "Marquis," the kind which "for twenty years made Cana-

dian wheat the standard for excellence in the world", will always be associated with the name of Saunders. The pioneer genetic work of Sir Charles on the inheritance of awns in wheat, published in 1904, can be linked with recent work in Western Canada by Thompson on the hybridisation of different species of wheat and related grasses.

Other important work associated with wheat includes researches by Newton, Scarth and others on frost-resistance of plants and the many investigations which centre around disease-resistant varieties and problems relating to rust. Particular mention should be made of the Dominion Rust Research Laboratory at Winnipeg, where work extremely valuable both scientifically and economically has been carried out. This is only one of many well-staffed regional laboratories, which investigate special crop problems. These and some twenty-nine entomological laboratories scattered throughout Canada all date back to the work of William Saunders, and of Fletcher, a man who after three years in charge of the Entomological Service (organised in 1884) became Entomologist and Botanist when the Experimental Farms were formed. In 1909 in a re-organisation Güssow became Dominion Botanist, and Hewitt Dominion Entomologist; and in 1914 the Division of Entomology of the Farms Branch was made a separate branch of the Department of Agriculture. Mention should here be made of the Institute of Parasitology at McGill University, and of the Imperial Parasite Service at Belleville, Ontario, where, under the direction of Thompson, both practical breeding of insects and fundamental research concerning their habits is carried out. Insects from here are sent all over the world.

The appointment in 1893 of E. E. Prince, formerly marine biologist at St. Andrew's, Scotland, as Dominion Commissioner of Fisheries was a significant event in the development of this branch of science. In 1899 he became Director of the first Canadian Marine Biological Station, from which developed the Biological Board of Canada, now known as the Fisheries Research Board. Through the supervision of this board, which now controls at least seven biological stations, a vast amount of work relating to the scientific administration and conduct of the fisheries of the Dominion has been accomplished, and many important investigations extending man's knowledge of life in the sea have been carried out. According to A. G. Huntsman of the University of Toronto, the most active of more recent workers, "although one of the last countries definitely to undertake fisheries investigations, Canada may now (1932) well be said to be in a number of directions in the forefront of such work among the nations of the world." Although the primary aim of the Board is "economic", it has always been in close touch with universities and has stimulated much work of fundamental importance. To quote Dr. Huntsman again: "Bacteriologists, biochemists, chemists and physicists have been conducting fundamental researches in relation to the holding, freezing, salting, drying, smoking, and canning of fish, an almost virgin field." Although this statement dates back to 1932, it gives a fair picture of one side of the work of the Fisheries Board.

[To be concluded

Scientists in New Year Honours

AMONG the scientists to receive awards in the New Year Honours List was Professor A. N. Whitehead. Well known for his philosophical works—his most famous book is probably *Science and the Modern World*—he was professor of applied mathematics at the Imperial College of Science and Technology before going to America where he became professor of philosophy at Harvard, a post he held for 14 years. He is aged 83.

The knighthoods include Dr. E. B. Bailey, Professor James Chadwick, Dr. A. P. M. Fleming, Professor E. H. Minns, Dr. R. E. Stradling, Brigadier L. E. H. Whitby and Professor E. T. Whittaker.

Dr. Bailey has been director of the Geological Survey since 1937. Professor Chadwick was assistant director of research at the Cavendish Laboratory before taking the chair of physics at Liverpool University; a collaborator of Rutherford, his name is associated with the discovery of the neutron, and his work on nuclear physics won him a Nobel Prize in 1935. Dr. Fleming is director of research and education in Metropolitan Vickers Electrical Co.: he was responsible for developing the works school and apprenticeship scheme, for which the firm has a world-wide reputation, and his honour is evidently to be connected with his work of relating vocational training to the new Education Act. Professor Minns, president of Pembroke College since 1928, succeeded the late Sir William Ridgeway as Disney Professor of Archaeology at Cambridge in 1927, an appointment he held until 1939: he has long been recognised as the world's foremost authority on the archaeology and history of the Scythians and the related problems of the cultural origins of the Russian peoples and the races of Central Asia and China. Dr. R. E. Stradling, who was seconded from the Building Research Station to become chief adviser to the Civil Defence research and experimental section of the Home Office (now the research section of the Ministry of Home Security), was recently appointed scientific adviser to the Ministry of Works. Brigadier Whitby, lately bacteriologist at the Middlesex Hospital, won fame for the clinical trials involved in the development of M and B 693; his knighthood is conferred "for services in the development of the sulphonamide group of drugs". Dr. Whittaker is professor of mathematics at Edinburgh University and is the ex-president of the Royal Society of Edinburgh.

A knighthood is conferred, too, on Dr. C. W. B. Normand, officer on special duty with the India Meteorological Department and formerly Director-General of Observatories, Government of India.

Colonel Sir Stanley Angwin, engineer-in-chief of the General Post Office, receives a K.B.E.

Readers familiar with the articles of Ritchie Calder, who before the war used to write on science for the *Daily Herald* and who has been very active on behalf of the Social Relations Division of the British Association, will be interested to learn that he has been awarded the C.B.E. for his services to "a department of the Foreign Office".

O.B.E.s go to Dr. Francis A. Vick, assistant director of scientific research, Ministry of Supply, and to Dr. Frederick Calland Williams, principal scientific officer at the Telecommunications Research Establishment, Ministry of Aircraft Production. Another recipient of the O.B.E. is Professor T. E. Jessop, professor of Philosophy and Psychology at Hull University College, for the work he has done in connection with adult education for the Forces. Dr. May Smith, lately investigator of the Industrial Health Board, Medical Research Council, is similarly honoured. Dr. James Taylor, assistant manager of the research department of I.C.I. (Explosives) Ltd., and Dr. William J. Dunning, armament research worker, Bristol University, becomes M.B.E.s.

Burns: A major Problem of War Medicine

GEOFFREY LAPAGE, M.D., M.Sc.

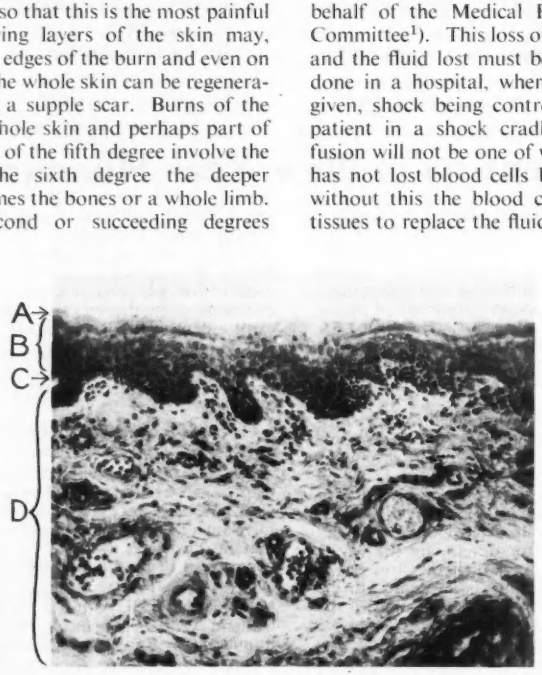
DURING the present war our soldiers, sailors and airmen have been exposed to constant and grave risks of severe burns inflicted by modern weapons, and much work on burns and their treatment has been done by medical men in consequence. "This is a burn war," said Lieutenant-Colonel B. Pollock, of the United States Navy, and progress in the treatment of burns represents but a part of the remarkable progress made in the whole field of medical work. It is possible to describe in a short article only some of the methods of treating burns which have been evolved during the last few years. Many of these methods are the direct result of war experience.

The brief description of modern treatment of burns which follows will be better understood if the changes which occur when a burn is inflicted are first briefly indicated. Burns may be of several degrees. Burns of the first degree cause only a reddening of the skin without destruction of tissue. They may be treated with any of the jellies now obtainable, which contain tannic acid, triple dye, dettol and other medicaments designed to cover them with a protective layer. Burns of the second degree destroy the surface layers of the skin and raise blisters, beneath which the cut is red and painful. Burns of the third degree destroy the surface layers down to the nerve endings, which they expose, so that this is the most painful degree of burn; the growing layers of the skin may, however, be preserved at the edges of the burn and even on parts of its surface, so that the whole skin can be regenerated to cover the burn with a supple scar. Burns of the fourth degree destroy the whole skin and perhaps part of subcutaneous tissues; those of the fifth degree involve the muscles; and those of the sixth degree the deeper structures, including sometimes the bones or a whole limb. When a burn of the second or succeeding degrees occurs, and especially if the area involved is extensive, the patient may suffer the following effects.

Shock may result from the damage done, from pain, from loss of fluid from the blood or from psychological causes. The first-aider has an important job to do in treating this promptly, and the importance of his work has been much emphasised recently. The patient needs to be kept warm, but not too hot, and may be given warm, sweet drinks. The burned patient needs fluid. Re-assurance will help to reduce shock by improving the patient's mental state. The relief of pain will normally be a job for a doctor. The first-aider should do no more than cover the burned area with a sterile cloth or at least a recently-laundered one, taking care that he has clean hands and avoiding as much as possible contamination of the burn with bacteria. Greasy or oily preparations should not be put on the burn. The patient should be taken to hospital or to a doctor as soon as possible and the doctor or hospital should be warned that the patient is on the way. It should be remembered that shock may be increased by uncomfortable means of transport.

For the relief of *pain*, morphia in quite large doses will be required if the burn is severe and it must be given by a doctor. The covering of the exposed nerves on the burned surface of third degree burns by subsequent treatment will further relieve the pain.

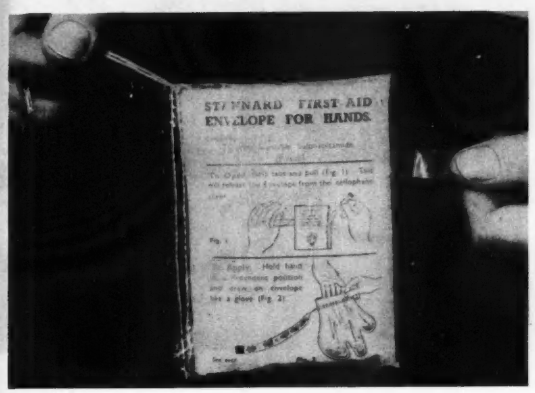
Loss of fluid occurs when the small blood vessels in the burned area are damaged and their walls become more permeable: fluid and plasma protein are lost both into the tissues beneath the burn and on to its surface. Swelling may follow, especially if the burn is on the face or around the eyes. (The whole question of loss of fluid from burns has been ably discussed by R. J. Rossiter, on behalf of the Medical Research Council's Burns Sub-Committee[1]). This loss of fluid must be quickly controlled and the fluid lost must be quickly replaced. This is best done in a hospital, where a transfusion of fluid will be given, shock being controlled meanwhile by putting the patient in a shock cradle or other device. The transfusion will not be one of whole blood, because the patient has not lost blood cells but has lost blood protein, and without this the blood cannot withdraw fluid from the tissues to replace the fluid lost. Blood protein will therefore be supplied in the form of plasma or reconstituted serum or dried serum made fluid again or one of the other blood substitutes now in use. Large amounts of plasma may be required. The amount needed may be calculated by estimation of the percentage of hæmoglobin in the patient's blood, from which the amount of plasma lost can be calculated. The patient may go on losing fluid, so that one transfusion will not be enough. Ogilvie,[2] for example, points out that severe cases may require, 8 to



The body's outer defences. The various skin layers shown in this photomicrograph are as follows: A, *the stratum corneum* which is horny; B, *the stratum granulosum*; C, *the Malpighian or growing layer*; D, *the dermis*, containing nerves, blood vessels, muscles, etc. Burns are classified according to depth of tissue destruction.

[1] *Bulletin of War Medicine*, 1943, 4,p. 181.

[2] *British Journal of Surgery*, April, 1944, p. 313.



(*Left*). The Stannard first aid-for-burns glove inside its envelope, with the two rip-tags which enable it to be quickly torn open revealing the glove within. (*Right*). The glove in use. Made of special oiled silk, it contains sulphonamide powder; pain-easing and so pliable that the hand can be used for writing, it is carried in British planes as part of the standard first aid equipment.

12 pints in the first 48 hours and 30 pints or more during first five days. The patient must be constantly watched the until the shock has been controlled and until the blood volume and the patient's general condition are considered good enough to enable him to stand the anæsthetic and operative measures which will be required. The administration of oxygen may be necessary.

Toxaemia, or absorption of poisonous products from the burnt tissues, may be a serious complication.

Sepsis, or bacterial infection of the burn, is, like toxæmia, very important. As *The Lancet*[3] has remarked, the majority of deaths after burns are attributable to toxaemia or sepsis. Infection with hæmolytic streptococci is especially dangerous. All those who treat a burn should therefore work with sterile hands and instruments and wear masks; in hospitals they must. Blankets, which are especially likely to be contaminated with bacteria, should never be allowed to come into contact with a burn, and air-borne infection should be avoided.

A variety of antiseptics have been used in burn dressings. Some doctors prefer relatively bland antiseptics, such as boric acid, for application to the cleansed burn surface, one of the sulphonamides, such as sulphanilamide, or in the United States, sulphadiazine, being at the same time given by the mouth. Others incorporate sulphanilamide in the burn dressing. Whenever this is done the concentration of sulphanilamide in the patient's blood must be checked throughout the treatment to prevent excessive and harmful absorption of sulphanilamide from burned surface. Penicillin is also used, either as a cream or as a powder used alone, or mixed with sulphanilamide powder. The limitations of both penicillin and sulphonamide drugs must be borne in mind. Some organisms including, *Proteus*, *Pseudomonas pycyanea* (the producer of blue pus) and various Gram-negative organisms, resist both, and to control these an effective antiseptic has not yet been found. The control of these organisms may result from further work on the anti-bacterial action of phenoxetol (ethylene glycol monophenyl ether) and of the quaternary ammonium detergent compounds, such as phemerol (phemeride), zephiran, and cetavlon or CTAB (cetyl trimethyl ammonium bromide).

Another antiseptic which has been suggested for burns is propamidine (4 : 4′-diamidino-diphenoxy propane). Both the dihydrochloride of this and the isethionate have been tried, the latter being rather less toxic, to judge from work done with it on rabbits. Some experts think there is little risk of the absorption of toxic quantities of propamidine from the surface of burns if the suggested 0·1% water-soluble jellies are used. Others give warnings about its possible toxic effects.

Turning now to the treatment of the burns, one of the most striking developments of recent years has been the almost universal condemnation of the use of tannic acid. There are two main objections to it. The protective layer which it forms over the burn tends to contract and to constrict the blood vessels, so that healing is delayed and healthy tissues near the tanned area—for example, the tips of the fingers—may die from lack of blood. Constriction may also lead to impairment of function and even to deformity, especially in regions such as the fingers and neighbourhood of joints. Tannic acid should, therefore, never be used for burns of the hands or feet, nor on the face, nor near the eyes. Secondly it has been shown that tannic acid can be absorbed from burned surfaces in sufficient quantities to cause serious damage to the liver. However, for minor burns, or burns of the first degree which do not expose the inner layers of the skin, tannic acid is still useful.

Treatment for burns now in use may be classified roughly into three main groups. First come the coagulant

[3] *The Lancet*, 1944, May 13, p. 633.

1.—Third degree burns on back, arms and in the a being irrig
22½% electrolytic sodium hypochlorite) by the Stant irrigation

2.—A close-up of third degree burns on the back, sh the heal
has occurred during one week of treatment with the yan-Stann

3.—A nurse taking a swab from a burned area prior t lying fresh
are present, so that an appropriate antiseptic may b sen.

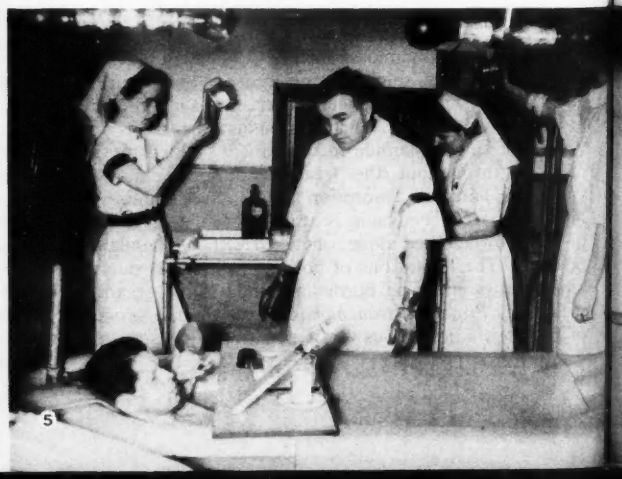
4.—The swab has shown that germs susceptible to p llin are pr
form of a cream.

5.—A burned patient comfortably seated in the sa bath after
allowed to smoke (through a holder to keep the smo way from h
the saline contents of the bath, while on the right an ly watches

6.—Sulphanilamide powder being sprinkled on to d areas f
sister holds tulle gras dressings which will cover the

7.—A burned patient in the saline bath having tulle dressings
from the hose keeps all uncovered areas moist.

8.—The dermatome in use for cutting skin grafts, wh equently h
semi-circular roller adheres to the fine layer of skin by the knife



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the back, sh the healing effect known as epithelialisation which
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area prior to ying fresh dressings in order to determine what germs
eptic may be en.

ceptible to illin are present, and this drug is being applied in the

ed in the sa bath after the dressings have been removed. He is
eep the smo way from his eyes). On the left a sister is seen testing
the right an ly watches the temperature control.

kled on to d areas following saline bath treatment, while the
ll cover the

having tulle dressings removed. Saline solution running gently
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n grafts, wh equently have to be applied after burn injuries. The
yer of skin c the knife and is then transferred to the burned area.

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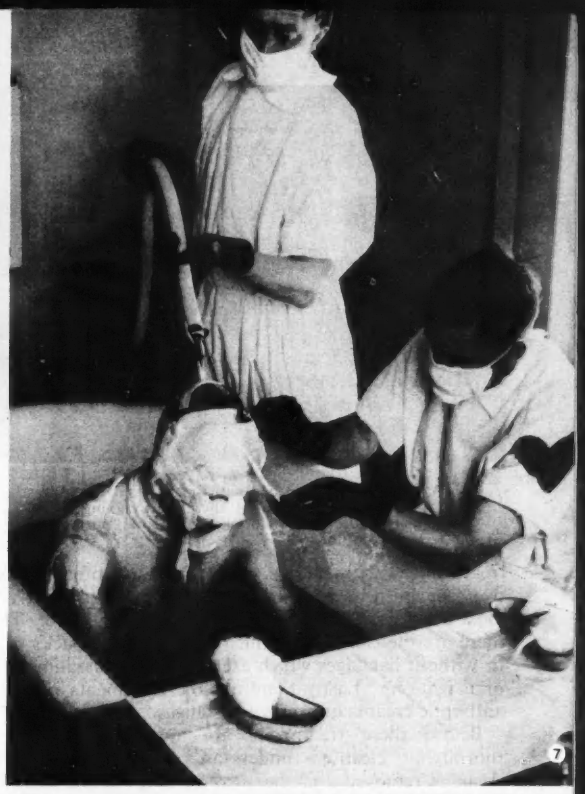

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A burned patient in bed with special arm extensions to prevent contraction of the tissues taking place. The restoration of function is an essential part of the treatment of burns.

A special bed-tent for the treatment of burns in a children's hospital. This type of warmth treatment is often used in coagulation therapy, the temperature of the tent being thermostatically controlled.

treatments with materials which form a protective layer over the burn as tannic acid does; the coagulant now most often used is the so-called triple dye mixture. Then there are the treatments which employ saline packs (with or without bandages which exert pressure) or saline baths or irrigations. Lastly there are the treatments involving antiseptic creams or greasy substances.

Before these treatments are applied, the burn is thoroughly cleansed under an anæsthetic. All dead tissue is removed and the surgeon takes swabs from the burned surface for bacteriological examination, so that he may know what bacteria, if any, are present and may choose his antiseptic accordingly. The heat of the burn may have partially sterilised the burned tissues, but he will not rely upon this for the control of sepsis. This is especially true of burns inflicted in war-time, which are grossly contaminated and may be complicated by fractures and other injuries requiring surgical treatment.

The triple dye mixture most often used in Great Britain consists of Brilliant Green 1%, Gentian Violet 2% and neutral Acriflavine 0·1%. These dyes are anti-bacterial and are sometimes used together with soap. The dye mixture is swabbed on to the cleaned burn surface and this first layer of dye is then dried on with an electric hair drier. Other layers are then applied and dried until a supple coagulum has been obtained. This is left on the burn until, after some 10 to 14 days, it separates spontaneously. If the burn has not destroyed all the growing layers of the skin, a healed surface will then be found beneath the coagulum. If the growing layers of the skin have been destroyed, healthy granulations will be revealed, and these can be treated as an ordinary healthy wound surface is treated, skin-grafting being commonly employed. Some experts use a combination of triple dye and a coagulum obtained with silver nitrate or tannic acid. A 1% solution of gentian violet is first applied and this is followed by two applications of either 20% silver nitrate or of 10% tannic acid. Whatever coagulant is used, the coagulum has to be watched daily, and its edges painted with triple dye daily, to prevent the occurrence of sepsis at the junctions of the coagulum and the unharmed skin. The dye method may, under some circumstances, be too slow, e.g. when artificial drying is not possible. At Tobruk, for example, it was abandoned for that reason. Burns were treated instead first with 10% silver nitrate and then with 10% tannic acid. Burns of the face, hands, joints and areas likely to get wet were, however, treated with sulphanilamide powder, and covered with soft paraffin-gauze, limbs being enclosed in plaster.

A number of other coverings for cleaned-up burned surfaces have been tried in recent years. As Lieut.-Col. B. Pollock has said, the ideal burn covering should be durable, non-contractile, indefinitely pliable, non-toxic, non-irritant, resistant to injury, bactericidal, painless, not unsightly and not costly to make. He reports a simple method of making dried sheets of blood plasma, which gave good results. Sulphonamide powder can be incorporated in these; they are transparent and require no dressing over them. Patients can, for example, take shower baths while they are in position, although dry dressings over them are desirable at night.

Experiments with Plastic Coverings

It is perhaps natural that some plastic materials should also have been tried for this purpose. In Canada fluids containing polyvinyl alcohol, methyl cellulose or both have been tried, together with sulphonamides, phemerol, triethanolamine, urea, and benzoic acid as antiseptics. It has been claimed that 8% triethanolamine with 2·5% sulphadiazine forms a supple, translucent covering which alleviates pain and avoids the need for frequent dressings, healing occurring beneath this covering in 10 to 14 days. Others have tried methyl cellulose with 10% sulphanilamide incorporated in the light, tough, pliable film which it provides; this is covered with a dry sterile dressing, but fluid exudating from the burn tends to break up the film. Cellophane has also been suggested for second degree burns, at any rate, for early treatment, one advantage claimed being that the progress of the burn can be watched through it. It does not, apparently, adhere to unhealed areas and can be readily removed and renewed. It is first sterilised by boiling (or put on after the burn has been dusted with sulphanilamide powder) and is then covered with oiled silk, cotton wool and a firm bandage to control

Saline Irrigation

the exudation of fluid. The cellophane covering of cigarette packets, put on with the inner surface next to the burn—this surface is likely to be cleaner—has been suggested as a first-aid dressing for burns suffered by soldiers for example. Another covering which has been suggested is viacutan, which is silver dinaphthylmethane disulphonate. It is claimed that this forms a coherent, flexible coagulum which does not crack, is easy to apply, relieves pain and is less liable than tannic acid to contract. It is also claimed that it inhibits the growth of some contaminating organisms.

The simplest form of saline treatment is irrigation with a saline fluid. This can be conveniently done by enclosing the burn area in a silken Bunyan-Stannard envelope and passing through this either a solution of electrolytic hypochlorite of soda or some other saline solution. Sulphonamide may be included in the irrigant. Such irrigations are given two or three times a day for 20 minutes or so at a time. After each irrigation the envelope is drained and dried by warm air or oxygen. Envelopes are made to suit all parts of the body.

Other experts use saline baths in which movement of the parts affected is encouraged to facilitate restoration of function. This after-treatment of a severe burn and rehabilitation of the patient is important. The Stannard Irrigation Company have produced a bed which can be converted, by means of coated silk sheets, into a bath, which will take the whole body. Three baths a day can can be given, each taking about 20 minutes. The patient wears a sterilised coated silk gown and never leaves the bed until the burns are healed or skin-grafting is possible. A method much favoured in the United States makes use of saline packs, which are firmly bandaged on so that pressure reduces the loss of fluid from the burn, especially if it is applied early. The method has been summed up as one of "cleansing, rest and compression." Sulphonamide powders may be included to control sepsis. Some use pressure bandages applied over sulphonamide cream put on to the cleaned burn surface. During war wet saline dressings have, disadvantages.

Yet other experts apply plaster or a splint to immobilise the part affected, the burn being treated with dry or vaselined gauze or dealt with much as an open surgical wound is treated. Others recommend, for war burns, cleansing of the burn, treatment with greasy sulphonamide preparations, immobilisation in plaster, and later, when conditions are more favourable, treatment with saline packs, pressure bandage and, subsequently, skin grafts. Advocates of the closed plaster treatment of burns, which is also used for the treatment of war wounds, claim that it prevents local swelling, promotes healing and minimises deformity.

Treatment by creams and greasy preparations may seem odd when so many warnings have been issued to the first-aider not to put such substances on to a burn. The point is that such substances applied after surgical cleansing of the burn, especially if they contain antiseptics (as they usually do), is very different from covering a dirty, uncleaned burn with them. Excellent results have for example, been obtained by the Burns Unit of the Medical Research Council, working in Glasgow, with the cream which they have evolved as the result of a long series of experiments. This cream contains the detergent cleanser cetavlon (CTAB)[4], which not only gets rid of dirt and grease but is also a very effective antiseptic.

It has not been possible in the space available to deal with the vitally important question of the preservation and maintenance of the function of the burned part of the body, which is always nowadays one of the main objects of those who treat severe burns; nor has it been possible to deal with burns caused by chemical agents, such as phosphorus, acids and alkalis. These latter are, however, dealt with in pamphlets and notices issued to workers especially exposed to the risk of them and to the Civil Defence Services.

The reader may have been astonished at the variety of the methods which have been successfully used for the treatment of burns. As *The Lancet*[3] points out, the surgeon who has to treat a burn must first consider the conditions under which he will have to work. The method he chooses will vary according to whether he is working in a well-equipped hospital, during an air raid, in an advanced dressing station, on board a battleship, in an air force hospital, and so on. He will also consider what nursing and other personnel are available for the after-care of his patient, whether the patient has to be transported elsewhere, whether sepsis can be readily controlled and a variety of other similar factors. Sepsis, toxæmia and shock will no doubt be the main risks to be combated.

It would hardly be possible to end this article with wiser advice than that given by *The Lancet*: "It is better to carry out a simple treatment correctly than to attempt something elaborate which does not quite come off."

[4] Its formula and the method of treating burns recommended by this committee are given in E.M.S. No. 8 (Revised), 1943, issued by the Department of Health for Scotland and in the Medical Research Council's War Memorandum, No. 10, on the Medical Use of the Sulphonamides.

Turning Ammonia to Peace-Time Uses

THE war-time demand for the explosive compounds of nitrogen has led to inflation of ammonia production throughout the world. Commenting on this important development in the *Annual Reports on the Progress of Applied Chemistry* (recently published by the Society of Chemical Industry), P. Parrish and F. C. Snelling, both well-known British chemical engineers, suggest that after the first two years of the armistice there will be an abundance of synthetic ammonia in the British Empire and the U.S.A. This surplus, they suggest, may not only constitute a challenge but indeed may afford an opportunity for developing new uses. This theme is taken up in the American Chemical Society's journal, *Chemical and Engineering News*, which predicts a huge post-war expansion in the consumption of ammonia. "Quick-freezing of foods and refrigeration are certain to require more ammonia than before the war. In frozen foods alone, production has grown tremendously—from 169 million lb. in 1938 to 960 million lb. last year. Refrigeration commonly means the manufacture of ice and the cooling of cold-storage plants, but ammonia also provides refrigeration for some important industrial processes such as petroleum refining, the manufacture of certain synthetic elastomers and the nitroding of steel. Under the necessity of providing enormous war production figured in terms of the finished materials, we have lost sight of these and other essential roles performed for industry by ammonia". America can now "fix" 775,000 tons more nitrogen than in 1939.

Micro-organisms on Production

A SURVEY OF INDUSTRIAL FERMENTATIONS*

G. COLMAN GREEN, B.Sc., F.R.I.C., A.M.I.Chem.E.

ALCOHOL has been shown to be of extraordinary importance to our civilisation in many diverse respects. It is unique in one other respect: it is not only the product of one major industrial fermentation, but it is also the raw material of another industrial fermentation of the highest importance, namely, the manufacture of acetic acid. This conversion is brought about industrially through the agency of one or another of the species of bacteria of the genus *Acetobactor*. This is a versatile genus of bacteria which, under appropriate conditions, can accomplish a number of delicate biological oxidations which cannot be achieved at all, or only with difficulty, by purely chemical means. Among these oxidations the most extensively applied is the oxidation of ethyl alcohol to acetic acid. The production of acetic acid by this means, in the shape of vinegar manufacture, has been known since early times, but it was not until 1837 that Kützing suggested that the change was brought about by living organisms, an observation confirmed by Pasteur in 1868.

Quick Vinegar Process

There are a number of techniques by which the process may be conducted, the most important being the "quick vinegar process". This process is of particular interest, not only on account of its great commercial importance, but also because the technique is related to certain industrial fermentations to be discussed later. The reaction is essentially aerobic, and a fundamental requirement is an adequate supply of air. This air serves not only to supply the oxygen necessary to, and remove the carbon dioxide resulting from, the organism's respiratory activity, but also to remove the heat evolved by the exothermic chemical reaction involved, the accumulation of which would gradually slow down the activity of the organism and ultimately destroy it. In the quick vinegar process these requirements are satisfied by spraying a dilute aqueous solution of alcohol over beechwood shavings (or some other suitable "packing") in a chimney-like vat. A culture of the organism desired has already been implanted on the surface of the shavings, over which the alcohol solution now trickles as a film and gradually becomes oxidised to acetic acid. The air passes up the vat counterflow to the surface of the liquor, an upward current having been induced by the heat of the reaction and the shape of the vessel. Alternatively, the air is blown in by fans or compressors, and this leads to the use of a more compact type of vat. Conditions are nicely adjusted so that, by the time the alcohol reaches the bottom of the vat (or the bottom of the last vat of a series) it has all been oxidised to acetic acid, the whole vat being kept at a pre-determined optimum temperature.

That the shavings (or whatever other supporting medium is used) should be adequate for their function is of the highest importance for satisfactory operation. On this supporting medium the organism developes a "zoogleal mat" in which each bacterium is surrounded by a gelatinous capsule. The slimey mass thus formed is known as "mother of vinegar". This can be made to serve a corresponding function with yeast barm in the sense that the product of one fermentation may be used to inoculate the next; but such a system requires suitable control, as unwanted infecting organisms may also be propagated by such means. In one of his classical investigations Pasteur showed that, if the support for the organism was not adequate, the "mat" would break away and the fragments carried away by the current of liquor would become submerged. In such circumstances the air necessary to the aerobic fermentation would have only limited access, and anaerobic fermentation would develop to oxidise the acetic acid to carbon dioxide and water, so reducing the yield to a serious extent.

FIG. 14.—*Acetobacter aceti*, the organism typical of a number of related species responsible for the oxidation of ethyl alcohol to acetic acid. Magnification × 750. *Photomicrograph by courtesy of Dr. A. C. Thaysen.*

Thus it is seen that two separate fermentations are necessary in acetic acid production, each of which is carried out by different organisms. If vinegar be required then the usual fermentation of malt wort by yeast (often a wine yeast, *Saccharomyces ellipsoideus*) is first carried out without the addition of hops. The beer is then turned to vinegar by the technique described. The flavour of the vinegar is due as much to the organism used as to the medium, and usually contains one or more of *Acetobacter, A. pasteurianum, A. xylinium*, etc. On the other hand, if acetic acid *as such* is required, the cheaper molasses are fermented and the beer or wash is converted to acetic acid by the technique described above. The acid is recovered as "glacial" acetic acid (100% pure by distillation or solvent extraction methods, or by a combination of both. Where the final product is to be glacial acetic acid, high yields are more important than aroma or flavour, and so a pure culture of one or other of the acetic acid bacteria is used. The modern tendency, however is to produce pure acetic acid by catalytic vapour-phase oxidation of alcohol, the alcohol usually being obtained by molasses fermentation.

Acetic acid has extremely wide application in industry. The acid enters into combination with alcohols to provide a wide range of esters, of which butyl acetate and amyl acetate are important examples. These are used as solvents in the paint, lacquer and varnish industry. A major use is in the manufacture of artificial silk of the "cellulose-acetate" type, of which the best known is "Celanese". The acetate-rayon industry consumes large quantities of alcohol as a solvent, and also considerable amounts of acetone in the spinning baths; in Britain this acetone is derived from acetic acid by dry distillation of its calcium salt, although it might also be obtained from the butanol/acetone fermentation described in last month's DISCOVERY. In the production of the cheap artificial silk which plays so great a part in our civilisation, it is of the utmost importance that there should be ample supplies of cheap alcohol, acetone and acetic acid. To this aim much ingenuity has been applied, and will continue to be applied in post-war days.

Synthetic Vitamin C

An important industrial fermentation which provides a technological link between the fermentations depending on yeast and bacteria on the one hand and the mould fermentations on the other is that in which *dextro*-sorbitol (obtainable by electrolytic or catalytic reduction of glucose) is oxidised by *Acetobacter suboxydans* to *laevo*-sorbose. This operation is an essential biochemical step in a chain of pure chemical syntheses leading from glucose to ascorbic acid, or vitamin C. This biological oxidation was discovered by Bertrand as far back as 1896; but, as is so often the case, it remained of academic interest until further discoveries made in apparently unrelated fields endowed it with a practical importance. In this particular instance, there were to follow Gowland Hopkin's discovery of vitamins in 1912, Szent-Györgyi's isolation of pure vitamin C in 1928, and the synthesis of ascorbic acid in 1933 by

* Concluded from p. 374 of the December issue.

Haworth and his co-workers at Birmingham University. The synthesis having been accomplished, the most practical route for manufacture was found to be: glucose—→sorbitol—→sorbose—→ketogulonic acid—→ascorbic acid. So it was that Bertrand's observation became of practical importance after the passage of 38 years.

The oxidation was at first carried out in shallow aluminium pans, the bacteria being allowed to work undisturbed on the surface of the medium, where they formed a continuous pellicle in much the same way that the related vinegar bacteria form a "mat" on the beech-wood shavings. The ratio of surface area to volume was found to exert a marked effect on yield. This is not wholly unexpected when the high degree of oxygenation required is considered as well as the need for the sugar to diffuse from the remote parts of the medium in the tray to the pellicle, which process is made the more difficult as the depth of medium increases. This ratio of surface area to volume of medium will be found to be an increasingly important factor in the industrial fermentations yet to be discussed, and to have a profound influence on technique. As the ratio s/v (s and v being measured in square centimetres and millilitres respectively) approaches unity, these fermentations become more and more efficient. But, where a large bulk of liquor has to be handled on an industrial scale, it is clear that limitations are defined by what is practicable. In practice, the additional yields beyond a certain point, are cancelled out by the additional cost of providing and manipulating the surface which would be required by some of these pan fermentations.

Shortly after the surface fermentation had become established for the purpose of providing sorbose for the synthesis of vitamin C, a great deal of attention in the U.S.A. was directed to the production of gluconic acid by a mould fermentation. This particular fermentation owed much of its derivation to the citric acid fermentation, to which we must now turn our attention in order to follow how the technique has developed.

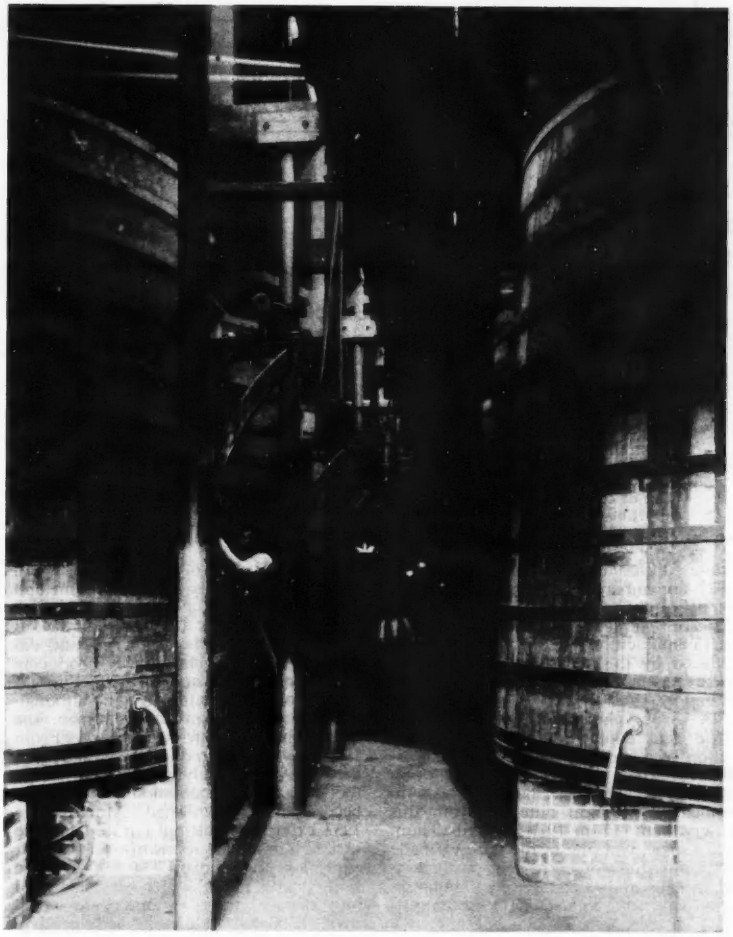

FIG. 15.—Vinegar manufacture. A view of fifty acetifying vats in an important vinegar works in the Midlands. The central section of each vat is packed with small bundles of birch twigs to provide a large surface on which the oxidation of the ethyl alcohol to acetic acid takes place. Fermented barley malt wort is repeatedly sprayed over the packing by automatic pumps until the required degree of acidification is obtained; this may take up to a month. *Photograph by courtesy of Hill, Evans and Co. Ltd., Worcester.*

Citric Acid Production

Moulds have long been used in the Orient in brewing the beverage *saké* from rice, but the development of *industrial* fermentations based upon moulds is confined to the period between the two wars. The chief characteristics of mould growth are the high degree of aerobiosis—that is, the organisms require the presence of oxygen if they are to thrive—the formation of a thick crinkled surface "felt" or *mycelium* consisting of interwoven "threads" or *hyphæ* from which, under certain conditions, aerial hyphæ develop which are tipped by the sporing heads. Within limits the colour and shape of the sporing heads enable us to identify moulds; for instance, moulds of the genus *Penicillium* have spores of a bluish-green colour while the genus *Aspergillus* are the black moulds commonly met on spoiling foodstuffs.

Until the beginning of the present war the most important mould fermentation was that which yielded citric acid, a substance used in confectionery and beverages. Citric acid has other uses in medicine, in foodstuffs manufacture generally, and in the form of its esters as a solvent and plasticiser in the plastics industry. In U.S.A. 65% of the peacetime consumption is stated to be used in medicinal preparations, 15% in foodstuffs and 9% in confectionery, leaving 11% unclassified. No doubt consumption in this country is roughly similarly distributed. Recurrent attempts have also been made to use citric acid or its derivatives in artificial resin manufacture and this may be a future potential use. Citric acid was formerly supplied from Sicily, and to a lesser extent from the Italian mainland, as a by-product of the lemon industry. The acid was recovered by precipitation, in the form of its calcium salt, from the juice of lemons unsaleable as fresh fruit and from the pulp remaining after the lemon oil has been extracted from the peel. Crude citrate from this source represented 90% of the world's supply in 1922, the sale being controlled by the Italian Government through the Camera Agrumaria which was set up in 1908 with headquarters at Messina. With the rise to power of the Fascist Government, the Italians decided to take advantage of their virtual world monopoly of crude citrates by reserving to themselves the further profit on the conversion of the

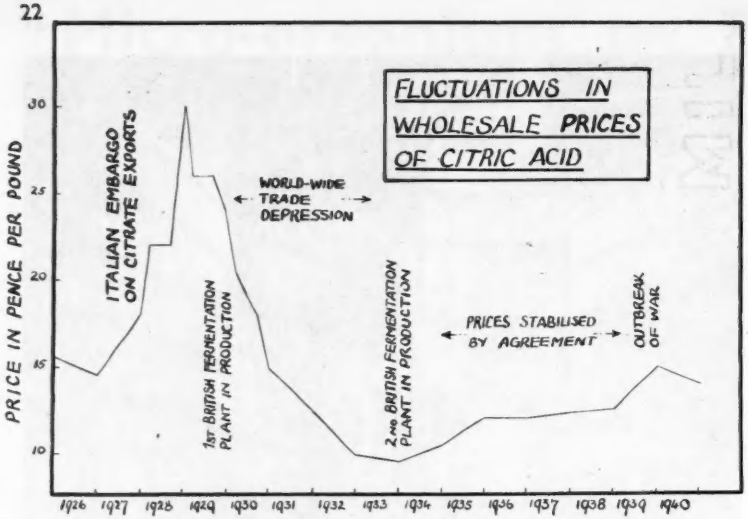
FLUCTUATIONS IN WHOLESALE PRICES OF CITRIC ACID
PRICE IN PENCE PER POUND
30
25
20
15
10
ITALIAN EMBARGO ON CITRATE EXPORTS
WORLD-WIDE TRADE DEPRESSION
1ST BRITISH FERMENTATION PLANT IN PRODUCTION
2ND BRITISH FERMENTATION PLANT IN PRODUCTION
PRICES STABILISED BY AGREEMENT
OUTBREAK OF WAR
1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939 1940

FIG. 16.—This graph illustrates in dramatic fashion the sudden increase in the price of citric acid in Britain which resulted from the Italian embargo on the export of raw citrates. The effect on the scarcity price level of the first British fermentation plant coming into operation is quite apparent.

crude citrates to pure citric acid, and in 1927 an embargo was placed upon the export of citrates, citric acid being offered instead. The inevitable consequence was that manufacturers throughout the world, reduced by this measure to the role of mere agents, sought alternative sources of supply.

In 1893 Wehmer had discovered that citric acid could be produced by the action of a mould he classed as "*Citromyces*" (now *Penicillium sp.*) upon glucose or cane sugar, but there was no immediate practical outcome from this observation. From 1916 onwards Thom and Currie, working in the U.S.A., made a careful study of citric acid production by moulds and laid a sound foundation upon which the industry later developed. They found that moulds of the two genera *Penicillium* and *Aspergillus* produced citric acid (members of the latter genus gave the best yields) when subjected to precisely controlled conditions of temperature, acidity, concentration of sugar and other nutrients, and so on. The fermentation has been found to be very sensitive to the presence of some metals in quantities so small that they can only be detected by the spectroscope and to the absence of others. It was also discovered that within the individual species were strains which, while morphologically indistinguishable, were capable of biochemical differentiation, a common and complicating feature of mycology.

One of the difficulties in the early work was the simultaneous production of oxalic acid which, of course, is toxic and difficult to separate from citric acid. Indeed, oxalic acid was known to be a product of mould metabolism some years before the presence of the accompanying citric acid was detected. In the modern citric acid industry this oxalic acid formation is entirely suppressed by careful selection and rigid control of conditions, especially those relating to the proportions of the nutrients in solution, the acidity of the medium and its temperature.

The U.S.A. was the first country to respond to the Italian embargo, and did so in no uncertain fashion by producing 4,500 tons of citric acid in 1929; this was mainly of fermentation origin, although a small balance was derived from the Californian citrus-fruit industry. From 1927 onwards no imports were made into the U.S.A. from Italy, so it is evident that the industrial fermentation had by then become firmly established. Moreover, in 1933 exports of calcium citrate from the U.S.A. amounted to nearly 5,500 tons, equivalent to just over 3900 tons of citric acid, nearly all of which was imported into Britain; these exports were worth over £300,000 but this remunerative business disappeared in the following months as the native British manufacture expanded.

Production of citric acid in Britain by fermentation had its origin in a patent which was taken out in 1927 by Fernbach, Yuill and Rowntree. (Fernbach has previously been mentioned in this article in connection with his work on the butyl alcohol/acetone fermentation). To J. L. Yuill, biochemist on the staff of Rowntree and Co. (the confectioners of York) who had the assistance of his brother E. Yuill as mycologist, is due the credit for accomplishing the industrial development in this country. This they had satisfactorily attained by 1929, when Messrs. Rowntree and Co. fused interests with John and E. Sturge Ltd., the Birmingham chemical manufacturers, who had been processing Italian raw citrates for a century until the embargo was placed on their export. The novelty claimed in the patent, which was exploited by large-scale production at York from 1930 onwards, was the high acidity of the medium which so inhibited the development of competing organisms that the selected strain of *Aspergillus niger* could carry through the fermentation without infection developing, thus obviating the costly sterilisation of the medium that is otherwise necessary. The imports from the U.S.A. noted above are explained by the fact that the second of the two English citric acid manufacturers received calcium citrate from America, until the American process was later established here by them. Fermentation processes have also been developed in Belgium, Germany and Czechoslovakia and, amusingly enough, the Italians operated at least one plant, having been forced to adopt the industrial fermentation which they themselves had provoked into existence—to their detriment.

The graph in Fig. 16 shows in an interesting fashion the effect of the Italian embargo and the development of the industrial fermentation upon the prices of citric acid during the vital years.

Throughout the world manufacturers endeavour to keep the working details of this process a secret. This is not surprising when it is remembered that the economic success of these mould processes, as has already been pointed out, turns upon successful handling of the great surface areas involved under sterile conditions. The general principles of the fermentation and of mould metabolism requirements in general are now well known. The secrets of the citric acid manufacturers, against which there are constant complaints, refer to small (but important) variations of these general principles together with manipulative details both of which have been accumulated at no small cost in time, money, and bitter experience.

It is generally known that the citric acid fermentation is carried on by selected strains of *Aspergillus niger* working on a modified Czapek-Dox medium* (in this case containing sucrose), which is the basic medium for modern mould fermentations, the process being worked in shallow pans of high-purity aluminium. Spores of the selected organism are sown on the surface of the medium, and these germinate and ultimately form a "felt" which grows to over an inch in thickness. The fermentation is complete in about nine days, after which the citric acid liquors are collected and the "felts" hydraulically squeezed and leached to recover the substantial quantities of citric acid that is held in the interstices of the mycelium.

Attempts have been made to cheapen the process by using molasses either in trays or impregnated into absorbent materials such as dried exhausted sugar-beet slices, Irish Moss and so on; in the latter variants it is seen that an attempt has been made to increase surface area relative to volume. Nevertheless, for

* Czapek's medium was devised to supply all the elements needed for mould growth without duplication; as modified by Dox, and later by Thom and Church, it contains sodium nitrate, potassium chloride, magnesium sulphate, ferrous sulphate and potassium monohydrogen phosphate, these salts totalling some 4 grams, in 1000 cubic centigrams of water. Various amounts of different sugars can then be added.

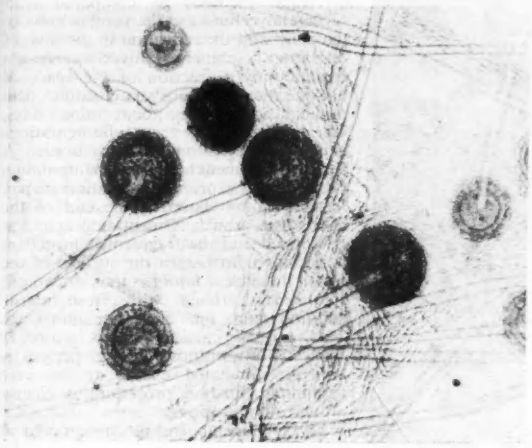

FIG. 17.—*Aspergillus niger*, showing hyphae terminating in conidiophores or sporing heads. The spores are black, as the specific name indicates, and the black sporing heads give the colonies their familiar macroscopic appearance. The individual spores (conidia) are spherical. Magnification × 100. *Photomicrograph by courtesy of Mr. George Smith.*

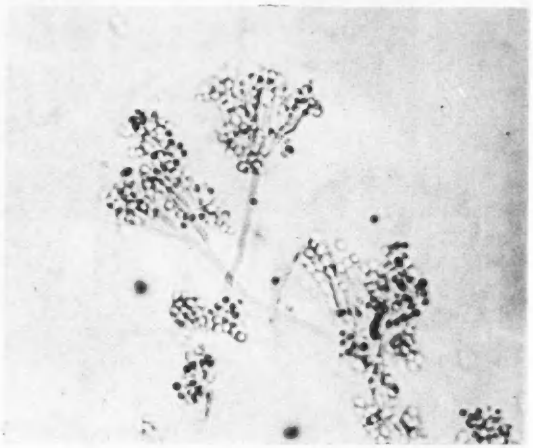

FIG. 18.—*Penicillium notatum*. A sporing head or penicillus (L, *a little broom*) of the famous Fleming strain which is used for penicillin manufacture. Compare the characteristics of this typical sporing head of the genus *Penicillium* with that of the genus *Aspergillus* in Fig. 17. *Photomicrograph by courtesy of Mr. George Smith.*

highest yields, for minimum production (indeed, the elimination) of undesirable by-products, and for ease in recovery of the citric acid from the fermentation liquors, sucrose, water and nutrients of high purity are used. Yields may in these conditions reach 65% (or occasionally higher) on the sugar used, or about 12 cwts. of citric acid per ton of cane sugar.

The successful industrial development of the citric acid fermentation renewed interest throughout the world in mould fermentation processes, and a fundamental re-examination of mould metabolism was undertaken by Professor H. Raistrick and his co-workers of the London School of Hygiene and Tropical Medicine; in the early days of these researches there was collaboration with the technical staff of the Nobel Explosives branch of Imperial Chemical Industries, Ltd., at Ardeer in Scotland. This important work, which commenced in 1922 and which Raistrick and his co-workers continue to develop to-day, has justifiably established a world-wide reputation for him and his school.

Gluconic Acid Fermentation

In U.S.A. the re-awakened interest developed into an elaborate study of the gluconic acid fermentation. It has already been indicated that this particular fermentation developed from the success of the citric acid fermentation; but in this case technique was carried a stage further from the pan-type of fermentation.

The recognition that it is possible to make gluconic acid by using micro-organisms dates back to the last decades of the 19th century. Boutroux in 1878 detected gluconic acid as a product of the action of *Acetobacter aceti* on glucose; but it was not until 44 years later—in 1922—that Molliard identified it in a mixture with citric and oxalic acids which resulted from the action of a mould, *Aspergillus niger*, on glucose. Just as oxalic acid production may be entirely suppressed in the citric acid fermentation by proper selection of conditions so, it was found, gluconic acid could be obtained exclusively in this new fermentation. To Bernhauer is due the credit for recognising in 1924 that by proper selection of conditions citric acid or gluconic acid could be obtained at will by surface fermentation. One of the very characteristic features of the fermentation was that sterile calcium carbonate should be present to neutralise the gluconic acid as it accumulated. Some of the conditions for high yield in the pan fermentation were an ample supply of air, a thin pellicle of mould, a low temperature and a low nitrogen supply. Where higher concentrations of

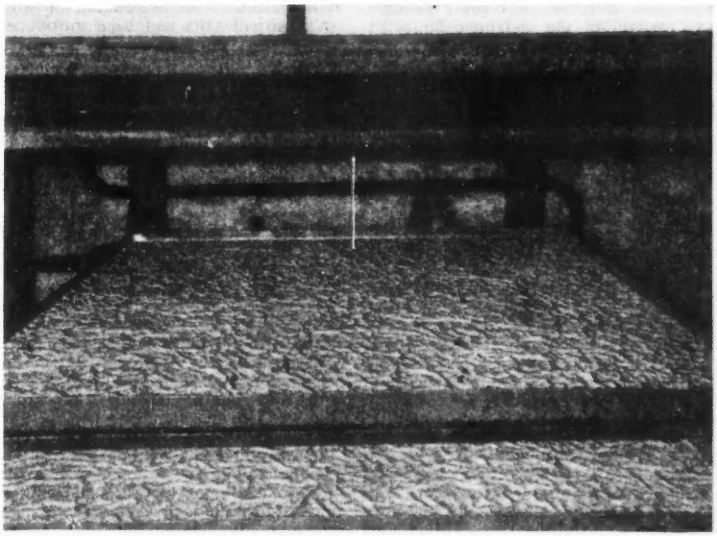

FIG. 19.—Gluconic acid fermentation as conducted in one type of shallow aluminium pan. Note the crinkled mycelium—the "mat" or "felt"—completely covering the surface of the culture medium. Vessels of this type, suitably modified, are used in the important fermentation producing citric acid. *Photograph by courtesy of Industrial and Engineering Chemistry.*

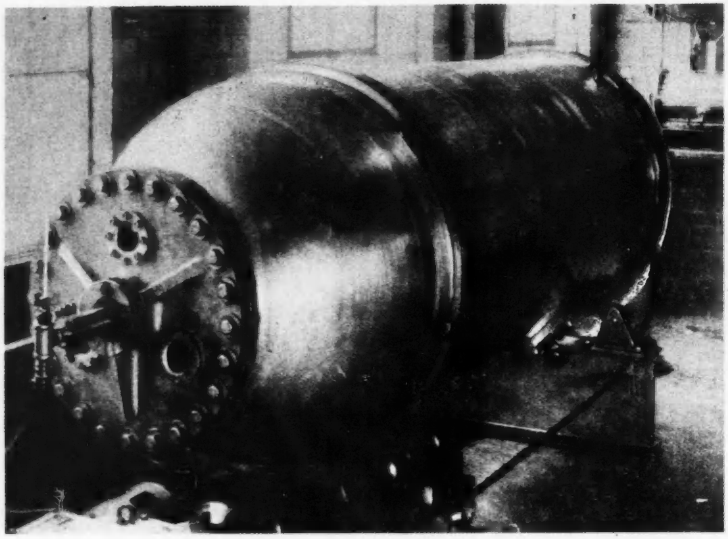

FIG. 20.—A rotating pressure vessel in which submerged mycelium fermentation is conducted for gluconic acid fermentation. This was an important advance on the tray technique shown in Fig. 19. *Photograph by courtesy of Chemical and Metallurgical Engineering.*

sugar were used gentle stirring of the medium was advantageous, as it assisted diffusional processes within the medium. This stirring had to be achieved without disturbance of the mycelium, fragmentation of which would cause it to sink and lead to reduction of yield. The stirrer was therefore introduced into the medium through a stationary sleeve, around which the pellicle could develop without risk of damage. An important refinement of technique made it possible to draw off of the metabolic liquor at a suitable point and to replace it by pure sugar solution with minimum disturbance to the "felt". By this means the "lag period" could be eliminated and the oxidation was immediately resumed without further utilisation of sugar in building up fresh mycelial material and with consequent enhancement of yield. This "priming" has an analogous operation in the brewery and has been extended to other pan fermentations.

Here, as in the citric acid fermentation, the selection and the maintenance of the strain of mould is of the highest importance. All too often an otherwise satisfactory strain turns out to be biochemically unstable; but, from a large number of moulds of the *Aspergillus* and *Penicillium* genus, May and Herrick and their co-workers in U.S.A. selected a strain of *Penicillium chrysogenum* catalogued as "5,034.11" as being the most satisfactory.

About 1928, Schreyer (working with *A. fumaricus*) and Currie (working with *P. chrysogenum*) discovered that enhanced yields could be obtained by agitating and blowing large quantities of air through the inoculated culture medium. By 1935 May, Herrick and their co-workers in the U.S.A. had developed a pilot plant based on this observation, and with this they were able to raise the yield from 55% of the theoretical yield (this figure was attained in pan fermentation) to 80%—or 97% on the sugar actually consumed—using *P. chrysogenum*. The submerged-mycelium fermentation, as it is called, was carried out in a horizontal cylinder, constructed of high-purity aluminium, which could be rotated about its longitudinal axis. After a solution of sugar and nutrient salts had been introduced, the whole was sterilised by steaming. Sterile chalk was then added, followed by a suspension of spores of the selected mould strain in sterile water. Rotation of the drum, combined with an arrangement of internal baffles, causes the contents, which occupy about $\frac{1}{3}$ of the total volume, to be broken up into droplets and thin films of liquor. Sterile air is blown into the apparatus at 30 lb. per sq. in. the volume passing through it per minute being equivalent to one-eighth to three-eighths the volume of the nutrient solution. The effect of this treatment is to break the mycelium into fragments; the pieces remain in suspension and do not form a pellicle. This enormously increases the surface of the organism relative to its volume and this additional surface is, of course, presented to the highly aerated medium. The yield is much enhanced by increasing the pressure of the air, but here again, as in the pan fermentations, one has to balance the value of the enhanced yield against the additional cost of procuring it. *A. niger* was preferred to *P. chrysogenum* because of the greater productiveness of spores required for inoculating displayed by the former.

The great advantages of submerged mycelium methods as compared with surface mycelium are the compactness of the plant and the reduction in the time of operation. Submerged mycelium vessels require only a fraction of the space of pan fermentations. Pan gluconic acid fermentations take about nine days, whereas submerged growth fermentations may take only about as many hours. A further refinement has been a manipulation paralleling the priming operation in pan fermentations. Towards the end of the submerged growth fermentation agitation is stopped and the fragmented mycelium is permitted to rise to the surface of the liquor; the clear liquor is then drawn off, the vessel primed with fresh sterile solution and the cycle recommenced. This can be carried out as many as thirteen times and the lag period is entirely eliminated except at the very beginning. Such a procedure is clearly an all-round economy.

So far gluconic acid has not proved of major importance in commerce. Its main application is in calcium therapy both in medical and veterinary practice. But it has been of the very highest importance in the development of industrial fermentation technique as outlined, the first extension of which was to the sorbose fermentation. The development of the latter to the first of the pan fermentations has already been discussed. Using *A. suboxydans*, Wells and his co-workers in the U.S.A. adapted the submerged mycelium technique to sorbose production with success. On an industrial scale this fermentation has been further simplified and cheapened by eliminating the cost of rotating the vessel. The agitation which is caused by suitably dispersed air blown into the medium is now reliable, and this further simplification is believed to have been also introduced to commercial gluconic acid production.

The most recent application of the submerged mycelium fermentation has taken place, interestingly enough, in the production of penicillin. Perhaps the most extraordinary development in the whole history of mycology has been the discovery of the bacteriostatic substances which are secreted by moulds in small quantities as one of the products of their metabolism. With the bacteriostats, as is so often the case in scientific discovery, one sees in retrospect foreshadowings of an event many years before the facts crystallise and take shape. As long ago as 1877 the great Pasteur observed the repression of *Bacillus anthracis* in a mixed culture, and similar observations were made by Twort in this country 25 years later. Just before the turn of the century Emmerich and Loewe observed that *Pseudomonas pyocyanea*, the blue pus bacillus, elaborated a substance, pyocyanase, which inhibited the development of certain disease-producing bacteria. In 1917 d'Herelle discovered bacteriophage, and preparations of this and of pyocyanase were actually marketed.

First Work on Penicillin

In 1922 Sir Alexander Fleming at St. Mary's Hospital discovered the powerful anti-bacterial substance "lysozyme" which

is quite widespread in animal tissues and secretions. This substance had a remarkable Rideal-Walker co-efficient (which is one co-efficient of efficiency of antiseptics) and, in addition, it had the most desirable and important properties of being active in the presence of serum and of not injuring tissues. Fleming had been preoccupied with problems of antisepsis, bacteriostasis and the immunological and other defences of the body against invading micro-organisms for many years; it is not surprising, therefore, that by a combination of experience and acuteness of observation he was able to note, in September 1928, the inhibition of growth of a Petri-dish culture of a *Staphylococcus* which had become inadvertently invaded by a spore of a green mould. He made a pure culture of this mould which was later identified as *Penicillium notatum*, Westling, a close relative of the mould *P. chrysogenum* used in the gluconic acid fermentation. Fleming made a preliminary investigation of the toxicity of the active substance secreted by the mould; he called it "penicillin" and proposed that its clinical use should be explored and went on himself to develop a differential culture technique for mixtures of certain pathogenic bacteria.

Efforts to Isolate Penicillin

The first attempts at isolation of the active principle secreted by this mould were made in 1932 by Raistrick and his co-workers. They found penicillin very unstable and difficult to isolate, but there is no doubt that, with the skill and facilities available, a satisfactory method of isolation could have been developed had sufficiently wide interest been displayed to provide the necessary justification and incentive for further work on this problem. But it appears that nobody showed sufficient interest in Fleming's discovery to warrant continuation of the work. It was eight years before the problem was revived, and it will be interesting to see what measure of blame for lack of receptiveness of this new development history will lay at the doors of the pathologists and clinicians.

It was not until August 1940 that Chain, Florey and their co-workers at Oxford University published a paper on penicillin as a chemotherapeutic agent and continued building on the foundation stone laid by Fleming nearly a decade earlier. The story of penicillin from this point onwards is the more striking because it has been carried through in the face of all the disabilities which the state of war places upon scientific workers engaged upon problems other than those connected with destruction. At the same time the state of war presented, in this specific case, just that urgent demand which has enabled the laboratory scale operations to be carried through to the industrial scale operations in the face of obstacles—among them, in this case, the financial ones loom large—which it would have been impossible to overcome in peace-time.

During the 1930's the Oxford group were much interested in Fleming's lysozyme which they isolated in a pure

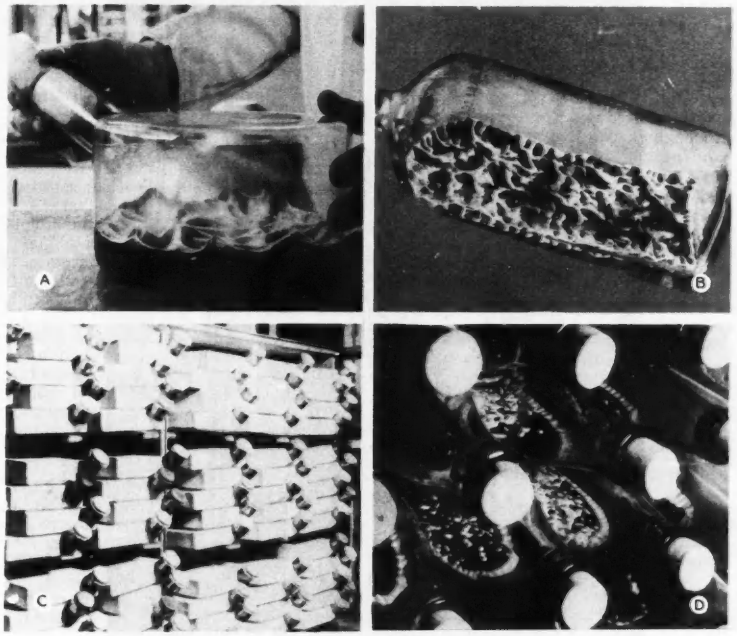

FIG. 21.—Various types of vessels used in the surface culture method of penicillin manufacture. A, glass vessel with two flat sides enabling the vessels to be stacked in tiers. B, Winchester Quart containing nutrient solution on which the mycelium floats. C, porcelain flasks as used in the early days of penicillin research and development (*Photograph by courtesy of Dr. E. Chain*). D, milk bottles, which have been used for large-scale production of the drug.

state. During this work their interest in the problem of bacteriostasis deepened and they resolved to embark upon "a systematic investigation of the chemical and biological properties of anti-bacterial substances produced by moulds and bacteria". This began in 1938, the first result being the paper mentioned above which was published in 1940. The properties of penicillin were found to be so remarkable that a large-scale laboratory production was embarked upon, an account of this being published in August, 1941.

One of the principle difficulties was found to be that certain bacteria abundant in the air secreted an enzyme, penicillinase, which destroyed the penicillin in the culture medium, and so extreme precautions had to be taken to avoid infection. A flat flask type of vessel similar to, but larger than, that used by bacteriologists was adopted. This type of vessel may be filled with medium through a suitably placed neck which can be closed with a plug of cotton wool to filter out air-borne infection. The whole may then be sterilised and, after cooling, the medium inoculated, the usual aseptic precautions being taken. One is not restricted to this shape of vessel and, as this fermentation has been put into larger scale production, less expensive vessels such as Winchester quarts and even milk bottles have been used though, perhaps, with some sacrifice of yield. Whatever the type of vessel used, the object, again, has been to place the vessel so that a large surface area relative to volume is obtained.

In the light of what has been told of the historical development of the aerobic fermentations it is not surprising that the question of the surface-volume ratio in penicillin production came up for early reconsideration. It is a sad thought that from this point until the present time the major process developments have taken place almost exclusively in the U.S.A. There are many reasons for this, not the least of which are the questions of man-power and the availability of material in this country—factors which are permitted to rear their heads in each war, as has been seen in earlier fermentation processes.

The pioneer experience of the British workers in the penicillin field was placed at the disposal of the Americans in 1941-42, since when eighteen plants have been brought into production in U.S.A. and three in Canada, with a total potential production of 200,000 mega-units per month.

C. E. Clifton of Stanford University was, in 1943, the first to publish suggestions for an approach from the standpoint of the "quick vinegar process"

• A Mega-unit equals a million Oxford units.

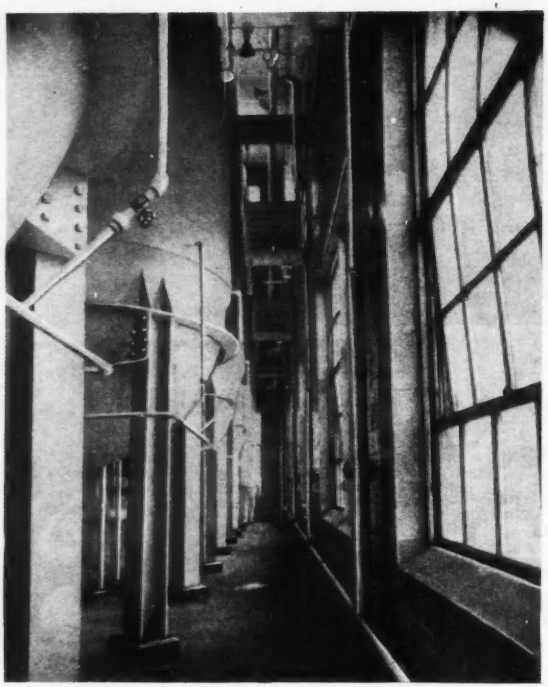

FIG. 22.—Sumberged mycelium production of penicillin—from the chemical engineering point of view a tremendous advance on the surface methods shown in Fig. 21. In these 12,000 gallon tanks, which are kept at about 75° F., the mould produces its maximum yield of penicillin in a few days.

which has been discussed. He constructed a laboratory size plant consisting of glass tubes, 4 ft. long and 2 in. in diameter which were packed with shavings on which he allowed the mould spores to germinate after the whole apparatus had been steam sterilised. The Czapek-Dox nutrient solution was percolated by gravity over the organism on the shavings whilst sterilised, conditioned air was passed counterflow up the columns. Penicillin was obtained in satisfactory yield. The chief obstacle in even this small-scale apparatus was the difficulty of assuring and maintaining sterility, and this would not seem encouraging to the projection of the method to a large scale.

Improved Production Methods

Meanwhile development along the lines already described for the gluconic acid and sorbose fermentations was explored and it was happily found that by submerged mycelium culture satisfactory production of penicillin could be obtained provided certain conditions were fulfilled. These conditions included, among others the addition of corn-steep liquor to the medium to be fermented, the use of lactose ("milk-sugar" extracted from the whey of the dairies) as the carbohydrate nutrient, and the selection of the most suitable strain of *Penicillium notatum*. Under suitably controlled conditions it was found possible to obtain a titre of 40 Oxford units per millilitre in two days as compared with 50-100 Oxford units in 6-7 days by the surface-mycelium method carried on in flasks or bottles. But what was more important, this type of plant lends itself to indefinitely large-scale development, which the surface type of fermentation does not do for the reasons already mentioned in connection with other mould fermentations. This has been a vitally important factor in enabling penicillin to be available in sufficient quantity to meet military requirements following the invasion of Europe last summer.

Three large plants producing penicillin are in operation in U.S.A., each utilising a deep fermentation system. The first is operated by Squibb & Co., who are well-known manufacturers of biological products of medicinal importance; the second is operated by Pfizer & Co., who pioneered in America the development of the citric acid fermentation; the third is operated by Commercial Solvents Corporation of America who have been already mentioned in connection with the development of the butanol/acetone fermentation. It is probable that none of these three factories produces less than 40,000 mega units per month. A replica of the penicillin factory as designed by the last-named company is at present being built at Speke, near Liverpool, and it will be operated by the Distillers Company as agents of the Ministry of Supply. It will cost £1,250,000, is due to come into operation during the early part of 1945, and may possibly produce penicillin to the extent of more than 120,000 mega units per month. The parent plant in America is reported to consist of ten fermenting vessels each capable of holding 12,000 U.S. gallons of liquor. In the extraction process that follows the fermentation, the penicillin contained in one 12,000 U.S. gallons charge is concentrated to a final volume of 15 U.S. gallons which yields after drying 4.5 to 5.5 lb. of dry penicillin. This dry penicillin, which is ready for medical use, contains about 1 to 2% of moisture and about 20 to 30% of pure sodium salt of penicillin, and has a titre of about 500 Oxford units per mgm. A vast quantity of air is blown through each of the 12,000 gallons charges and the steps taken to render this air sterile will make interesting reading when details are released. An enormous amount of work, too, has gone into designing the special vacuum pumps which have been designed to enable the penicillin to be "freeze-evaporated". This is a process which has been in use for drying heat-sensitive substances at such a low temperature that the water passes straight from ice to water vapour without becoming liquid first. The technique has been applied before in drying such delicate materials as blood plasma and serum; but it is doubtful whether it has ever been applied before on such a large scale and special vacuum pumps have had to be designed incorporating quite new features.

It is an interesting fact that the moulds used throughout the world in the surface culture systems are derived from Sir Alexander Fleming's original strain. This strain, however, gives indifferent yields when used in the submerged mycelium system for which a more satisfactory mould has been found in a collection formed by the U.S. Department of Agriculture. But this strain, in its turn, while giving very satisfactory yields in the submerged mycelium system gives only indifferent yields by the surface culture method.

As has been said, the recovery of penicillin from the metabolite liquor is carried out by solvent extraction at controlled *p*H's, and after removal of pyrogenic (fever producing) substances the solid sodium or calcium salt of penicillin is isolated by "freeze-evaporation". The best solvent so far found for the extraction of penicillin is the ester, amyl acetate, and so the ethyl alcohol fermentation, of which amyl alcohol is a by-product (referred to in the December issue of DISCOVERY), is recalled to mind. The rapidly increased demand for amyl acetate by the American penicillin plants has outstripped normal supply and acute shortage of the ester has developed.

The fringe of the problem concerning the antibiotic substances elaborated by micro-organisms—by bacteria and higher fungi as well as by moulds—has barely been attacked. It is becoming clear that the ability to produce antibacterial substances, albeit varying in potency and

toxicity, is widespread. Their physiological significance and mode of action are by no means clear, although recent work on the sulphonamides and other chemotherapeutic substances is throwing light on the latter. But, so far as our present knowledge goes, these antibiotic substances appear to be part of a mechanism, the net effect of which is to achieve antagonism between organisms, thereby assisting in the maintenance of the species, or even of the strain, in a competitive environment. The phenomenon contains elements which are the converse of those found in symbiosis, of which there are many well substantiated examples such as the association of algae and fungi in lichens. There is, therefore, a wide field among these lowly organisms awaiting, and, indeed, undergoing exploration. Such work is not made easy by the fact that the function of secretion of these anti-bacterial substances appears at the present time to be a question of strain and not of genera, species or other groupings, and this enormously expands the field which must be searched. The further development of industrial fermentations to produce penicillin, patulin, notatin, gramicidin, etc., as well as other antibiotics yet to be isolated, will be awaited with no less interest than the elucidation of their chemotherapeutic applications.

Lactic Acid and Glycerol.

To two other industrial fermentations only brief reference can be made. The lactic fermentation has long been known in the souring of milk, another phenomenon upon which Pasteur shed the light of his genius. While whey is available in fair quantity it is rarely used for industrial production, molasses being preferred. *Lactobacillus* is an enormous group, members of which operate over a wide range of temperatures. Therefore, in the industrial fermentation, organisms of the *L. delbruckii* type are used, as they are characterised by an optimum temperature in the neighbourhood of 50° C., the highest temperature at which any industrial fermentation is conducted. The advantage of this higher working temperature is that only thermophilic organisms can survive, so that the cost of sterilising the medium and of installing plant suitable for maintaining sterility is obviated. As in the gluconic acid fermentation, it is necessary to add chalk to the brew to prevent the accumulation of an inhibiting degree of acidity, though apart from that there is no parallelism between the two fermentations.

Lactic acid is mainly used as an acidulant, and is competitive, up to a point, with citric and tartaric acids for this purpose. It suffers the disadvantage that it is only available commercially in liquid form and is therefore not generally so easily transported, stored or handled. It has not become a serious competitor with these acids in the food trade. Its principle outlet is in the leather industry where it is used for the de-liming and plumping of hides in the tannery. It is not surprising, therefore, that the only plant in this country is situated in proximity to the one nucleus of the leather industry—the Mersey area. The esters of lactic acid find substantial uses in the plastics industry.

Finally, the production of glycerol by the yeast fermentation of sugars claims an honourable mention, although it is no longer of commercial significance and, indeed, is not likely to become so in view of the ample supplies of glycerine available from the world's highly organised fat and oil resources. Using sugar-beet juice the observation of Pasteur that about 3% glycerol was always formed in alcoholic fermentation was developed by Connstein and Lüdecke in Germany during the 1914-18 war to the point at which 1000 tons per month were being produced with a yield of 25%. The fermentation was developed by them as a consequence of the cutting off by the blockade of supplies of fats and oils, from which glycerine is normally derived, for the explosives and other industries; it is conceivable that Germany may have resuscitated the fermentation during this present war for the same reasons.

The fundamental importance of industrial fermentations to our civilisation will, by now, have been appreciated. In this department of applied biological science the last word is far from having been said, as recent developments which I have outlined indicate. Nor, one may speculate, will the last word be said until that remote day when the metabolic mechanism of the simple organisms used is fully understood. There appear to be periods of stagnation in technological development as for example between what may be called the Pasteur-Fernbach and the Fernbach-Florey phases. They are, however, more apparent than real, and do not reflect the great amount of fundamental work carried out by research workers in the lulls between the years when major advances are announced. With the increasing organisation of research which is expected in the post-war world and the removal of those factors, political and economic, which restrict the application of new discoveries, it is to be expected that the industrial fermentations may be increasingly developed.

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REFERENCES TO PENICILLIN

Since penicillin research is proceeding so rapidly and as many of the details about production are secret it is not possible to refer readers to any comprehensive monograph. The following articles are worth consulting: Chain, E., and Florey, H. W., *Endeavour*, 1944, **3**, p. 3; Williams, T. I., *Discovery*, July 1944, p. 201; Callaham, J. R., *Chemical and Metallurgical Engineering*, April 1944, p. 94, p. 129. The British Council's *British Medical Bulletin*, 1944, **2**, No. 1, was devoted entirely to penicillin, and contained articles by Sir Alexander Fleming, Dr. E. Chain, Sir Howard Florey, Dr. M. E. Florey and Professor L. P. Garrod. *Industrial Chemist* (Nov., Dec., 1944), contains a description of a British plant running the bottle process.

Scientific Training for Servicemen

IN the House of Commons on December 7 Mr. Bevin was asked about the omission from the leaflet PL 120—dealing with higher education for discharged Service personnel—of any reference to scientific and technical training. The Minister of Labour replied that, although not specifically mentioned in the leaflet, courses of scientific and technical training were included among the courses which will equip men and women to fill the higher posts in industry, commerce and the professions. "I am hoping to issue a revised leaflet at an early date", he added.

The War Office attaches great importance to the Army Education scheme that will cater for serving soldiers between the end of the German war and their demobilisation, and has released Brigadier Cyril Lloyd, C.B.E., from his post as Deputy Adjutant General to the 21st Army Group to take up his duties as Director of Army Education under the Director-General, Mr. P. R. Morris. Brigadier Lloyd, who is 38, is a B.Sc. of London University and has served on the staff of Sir George Monoux Grammar School and Brighton Grammar School.

Fears that this scheme and others that the Government is planning for the benefit of servicemen and women might be jeopardised by the shortage of text-books was allayed somewhat when the Minister of Education stated last month that paper quotas for the publishers of text-books and the Moberley reserve had just been increased by 633 tons, and a special allocation of 800 tons granted for the Services' post-war educational scheme.

The Night Sky in February

M. DAVIDSON, D.Sc., F.R.A.S.

The Moon.—New moon occurs on February 12d. 17h. 33m., U.T., and full moon on February 27d. 00h. 07m. The following conjunctions take place:

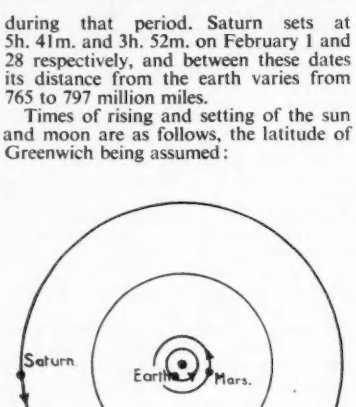
February

1d. 03h.	Jupiter in conjunction with the moon	Jupiter	4 °	S.
10d. 22h.	Mars ,,	Mars	0·1	S.
15d. 20h.	Venus ,,	Venus	8	N.
21d. 22h.	Saturn ,,	Saturn	0·6	N.
28d. 06h.	Jupiter ,,	Jupiter	3	S.

The Planets.—At the beginning of the month Mercury rises at 7h. 04m., about 36 minutes before sunrise, and is not an easy object to detect. At the middle of the month it rises about the same time as the sun. The planet is in superior conjunction on February 28, when it rises at 7h. 07m. Venus can be seen in the evening hours, setting at 21h. 10m., 21h. 35m., and 21h. 53m. at the beginning, middle and end of the month respectively. Mars rises about 50 minutes before the sun at the middle of the month. Jupiter rises at 20h. 54m. and 18h. 48m. at the beginning and end of the month respectively; its distance from the earth varies between 436 and 416 million miles during that period. Saturn sets at 5h. 41m. and 3h. 52m. on February 1 and 28 respectively, and between these dates its distance from the earth varies from 765 to 797 million miles.

Times of rising and setting of the sun and moon are as follows, the latitude of Greenwich being assumed:

February	Sunrise	Sunset
1	7h. 40m.	16h. 48m.
14	7h. 17m.	17h. 12m.
28	6h. 49m.	17h. 38m.
February	**Moonrise**	**Moonset**
1	21h. 22m.	9h. 43m.
14	8h. 33m.	19h. 36m.
28	19h. 10m.	7h. 48m.



Relative positions of the planets in the middle of February. The dot at the centre represents the sun.

The relative positions of the planets are shown in the diagram, the middle of February being assumed as the date, and from this it will be seen that Mars lies too close to the direction of the sun to be favourably observed.

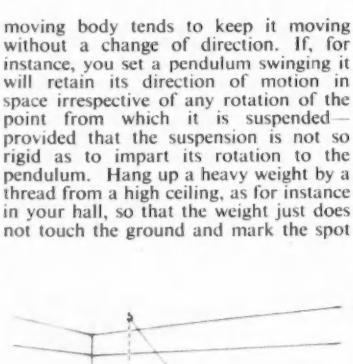
Those who possess a small telescope will find some interest in a few of the stars in the constellation of Leo, which is easily recognised as a portion of it is shaped like a sickle. The 2nd magnitude star γ has a companion of magnitude 3·5; the contrast in their colours is very striking, γ being a golden-yellow and its companion a greenish-red. Another double star worth observing is ι, magnitude 4, the bluish companion of which is magnitude 7 and so can be seen with a small telescope. The brightest star in the constellation, α, has an attendant at a distance of 3′, but as its magnitude is 8·5 it will not be so easy to observe as the others just referred to.

JUNIOR SCIENCE

Does the Earth Rotate?

OF COURSE it does; every school child knows that. The earth spins round on its axis—that is why we have day and night—and it also rotates around the sun. These simple facts which to-day are doubted by nobody were not always accepted as the truth, and most of you will know that a little more than 300 years ago Galileo was threatened with torture and death because he maintained that day and night were caused by the rotation of the earth. But if you were asked to prove that the earth spins round its axis in 24 hours, could you do it? If you were to say that we see the sun, the moon and the stars describing circles around the earth, that would be no proof, since it could be argued, as indeed it was in Galileo's day, that the sky together with all the heavenly bodies rotates around the earth which stands still in the centre. In order to prove the earth's spin you must be able to point out something that can be observed on the earth but which does not take part in the earth's rotation. Such things do indeed exist and you can prove that the earth turns around its axis by a simple experiment, which you can carry out in your own home.

As I told you recently, the inertia of a moving body tends to keep it moving without a change of direction. If, for instance, you set a pendulum swinging it will retain its direction of motion in space irrespective of any rotation of the point from which it is suspended—provided that the suspension is not so rigid as to impart its rotation to the pendulum. Hang up a heavy weight by a thread from a high ceiling, as for instance in your hall, so that the weight just does not touch the ground and mark the spot on the floor directly underneath it. Now pull the weight towards the nearest wall and fasten it with a thin cotton thread (see diagram). Mark again the spot on the floor directly under the weight and draw, with chalk perhaps, a straight line from this spot to the first one, but continuing beyond it. When you are sure that the weight is completely at rest burn the cotton with a match and set the weight swinging above the marked line. After about fifteen minutes you will be able to notice a slight deviation of the direction of the swing from the line, and after an hour this deviation will have become considerable. The earth has turned under your pendulum.



This method of demonstrating the earth's rotation was devised by the French physicist Foucault; he carried out the experiment in 1851, and four years later his ingenuity in this connection and also in the invention of the gyroscope was rewarded by the Royal Society of Britain which gave him the Copley Medal, a very high honour. Before the war a "Foucault pendulum" was to be seen swinging from the roof of the Science Museum at South Kensington, and you will have a chance of seeing it there again after the war.

K.M.

The Bookshelf

The Efficient Use of Fuel. Edited by G. E. Foxwell; (Stationery Office, 1944; pp. 807; 12*s.* 6*d.*).

THE majority of the energy needed to support industry and render home life possible in Great Britain comes from coal. Blast furnaces, brick kilns, glass lehrs, locomotives, industrial and domestic boilers, all demand fuel incessantly. In time of war our ability to produce arms is limited by the availability of fuel; in peace our standard of living is conditioned by the output per man hour of the industrial operative—an output which is raised by using more powered machinery. The efficient use of fuel is thus fundamental to our national existence. It is gratifying, therefore, that this new textbook has been produced to help forward knowledge of better methods among students and technical men in industry. The earlier book, published under Government auspices, *The Calculation of Heat Transmission* by Fishenden & Saunders, is now unobtainable and quotations from it are welcome in this new book, which also includes data from *Heat Transmission* by McAdams, the well-known and very valuable American textbook.

Heat transfer is only one of the subjects studied here. Alongside it is the flow of fluids; the brother theme which normally accompanies heat transfer in the introductions to standard works on chemical engineering. These are two topics which lend themselves to mathematical presentation and occasionally to academic aridity. But here the presentation is practical and with due regard to the best theory. Perhaps the most valuable of the more specialised material is that which deals with furnaces. This is a subject which has been very poorly treated in the literature, and there has been little attempt to achieve a sufficiently general approach, permitting the design of furnaces for new purposes from first principles.

The known facts regarding the production of heat by combustion are presented and, from the production of high-grade heat and operation of the equipment, there follows the important field of low-grade heat utilisation. It was in respect of low-grade heat recovery that one of the more famous of the contributions in this book made its mark—Oliver Lyle worked out the design of a factory for the recovery of red tape, showing how considerable heat economies could be made by the correct utilisation of low-grade recovery techniques! It is against the background of successful utilisation of low-grade heat in factories that the present wasteful methods of public electric-power generation must be viewed. It is cheaper for a factory which uses electricity and process steam to generate its own electricity than to purchase it from the outside suppliers. Why such parallel production and use of electricity and low-grade heat is not pursued by the public utilities must be closely examined and questioned, in view of the large number of new power stations which are projected.

Arising from the deficiences in present knowledge, which became obvious to the authors in preparing the book, there is promised an exploration of new paths. Perhaps there may also be a consideration in the proper quarters of the formation of an organisation concerning itself solely with heat transfer—similar in scope to the American bodies, the Hydraulic Institute and the Heat Exchange Institute. A Boiler Research Association for Britain is already rumoured. All such progressive steps are to be welcomed, in the same manner that this useful volume will be acclaimed. S.G.

From Atoms to Stars. By Martin Davidson, D.Sc., F.R.A.S., (Hutchinson, 1944; illus., pp. 188, 15*s.*).

THERE are almost as many books on various aspects of astronomy as there are White Papers. There are little books describing the constellations and giving something of the fundamentals of positional astronomy; there are rather bad books full of sensation and rows of zeros designed for the kind of audience which does not really want to understand, but likes a thrill out of the mysterious; there are books which are not really about astronomy at all, but which discuss the impact of new astronomical knowledge on philosophy or theology. There are very few books which seriously try to give an honest picture of the kind of problem with which the working astronomer is concerned, and which make an attempt at a genuine interpretation of what astronomy is all about.

Dr. Davidson's book comes in this last class and if we have to say that, for some reason of a rather elusive kind, it does not quite come off, nevertheless, this is a book to be recommended to the serious and intelligent reader, though he need not be learned. Let us be quite definite in saying that this is a well-written book containing a vast amount of material for its size, and will certainly give pleasure and information to its many readers.

It is so nearly what is wanted that it is a book to be taken seriously. Its defects are so slight that it is worth while thinking about them and trying to place them accurately. In the first place there is, perhaps, something a little wrong about the balance of the book. It has included most of the things which ought to be there, but a slightly old-fashioned note is struck in the relative allotment of space to the solar system and the rest of the universe. If the author intended to hold the mirror up to modern astronomical research, his glass is not quite accurate, for he has given too much importance to our own astronomical back-yard as compared with the system of the stars and the nebulae.

The second point concerns the problem of atomic structure, and no one who has not tried to solve it has any right to throw bricks at its exposition by anyone else. The fact is that you cannot deal with astrophysics—probably the most important field of modern astronomical research—without first giving some account of atomic structure. But if you give an adequate account, then there is precious little room left in your book for astrophysics. Dr. Davidson's solution of this dilemma is to put atomic structure nearly first, an arrangement which does not work out too happily. What else he could have done it is hard to see, but the fact remains that as a result the book does not run particularly smoothly here.

Very well: we have had our say, and split our hairs, and when all is said and done, the publishers will be quite justified in putting on the dust cover of the second edition, which will no doubt appear fairly soon, "This is an important contribution to the literature of popular science, written with integrity and skill by an astronomer who knows what he is talking about and how to say it". D.S.E.

Chemical Elements. By I. Nechaev. (Lindsay Drummond, 1944; illus.; pp. 151, 8*s.* 6*d.*).

THE cult of popular science writing is not particularly strong (it is a rare year that sees six first-rate books in this category published in Britain) and the reviewer is always at something of a disadvantage in not knowing whether strenuous use of the critical pruning knife will lead to new and vigorous shoots arising, or whether it will merely have the effect of discouraging publishers who are none too adventurous in this direction as it is. One would like to be enthusiastic about this book, for one senses through the cloud created by bad translation (frankly the book has been anglicised rather than translated) that the young Russian chemist Nechaev has a flair for this kind of writing. Had the whole been as good as the chapter on Mendeleev one would be able to recommend the book highly. The subject matter seems suitable for those who have not studied chemistry before or are just being introduced to it. The style is reminiscent of Paul de Kruif, but whereas adults are likely to take the dramatised approach with its imaginary conversations with a pinch of salt children may not be able to distinguish between what is fact and what is fiction. It was my impression that some of the time the style was just right for children aged about 12 to 14; in other places it seemed to err on the low side—with theories perpetually "popping" in and out of scientists' heads—and elsewhere it erred in the other direction with terms like "agro-chemistry" coming in too frequently. But it is very difficult to judge the anglicised version; perhaps the original was a very vivid piece of writing without any muddy or purple passages. The selection of illustrations is not good. Incidentally the book illustrates the difficulty of using the historical approach in science teaching, and those who advocate that method should read it. W.E.D.

Far and Near

Scientific Literature for France

WE have received the following letter, which was signed by Sir William Beveridge, Professor P. M. S. Blackett, Mr. E. Carter (Chairman of ASLIB), Mr. J. G. Crowther, Dr. C. D. Darlington and Sir Richard Gregory, appealing for copies of journals which can be forwarded to scientists in France.

"Scientists in liberated Europe need literature dealing with advances made in allied countries during the war. In particular French scientists need this material as quickly as possible. In Paris, there is gas and electricity for only one or two hours in the evenings, so that experimental work is hardly possible. To help these scientists, who have played an active part in the Resistance Movement, to use their time profitably until they can restart their laboratories, and as a gesture of friendship, we should like to send them copies of scientific journals published during the war. All material sent to France would be fully used. Literature would go to the Centre National de Récherche Scientifique in Paris, which is in touch with the whole body of French scientific workers. Single copies would be microfilmed, and films and abstracts distributed. Thus the greatest possible use could be made immediately of any periodicals that can be sent to them. We are therefore appealing to British scientists to give to their French colleagues copies of scientific journals, technical papers, reprints, etc., from January 1940 onwards. We know it is hard for scientists to part with complete sets of journals they have collected over years, but in this country there are well-stocked libraries which can be consulted, and this is not the case in France and the other newly liberated countries. We hope that there will be a generous response to this appeal. Sets of journals and single copies should be sent to: The Association of Scientific Workers, Hanover House, 73 High Holborn, London, W.C.1."

Imitating the Squid

A NEWLY-DEVELOPED chemical compound which officials of the U.S. Bureau of Ships believe will reduce the danger of attack by man-eating sharks is being incorporated into a packet which can be attached to any type of life-jacket, states the Navy Department, Washington. This shark-repellent has been tested in experiments conducted off St. Augustine, Marathon and the Florida Keys, Florida, and at Chandaleur Island, Louisiana, with very satisfactory results. In some of the tests duplicate lines were used, one having bait protected by repellent. Catches were made on the control line, but very few were made on the repellent line. Under the conditions of the experiment, the chemical compound was about 98% effective in reducing the strikes and catches. Its effectiveness proved high even when the sharks previously had been excited and made greedy by luring them with bait.

The repellent packet includes several chemicals compacted together with a water-soluble wax. Tests and observations have shown that sharks seldom attack dark-coloured objects and that the visual factor is important in the feeding habits of sharks; the inky fluid which diffuses from the packet has the added advantage of letting the user see the extent to which his protection extends so that he can stay within it. In addition, one of the constituents has a taste and smell distasteful to sharks.

Scientists and the Civil Service

THE Government has decided to retain after the war a central body of economists and statisticians such as been set up in the Cabinet offices during the war. This is disclosed in the statement of Government policy and the Civil Service National Whitley Council report published together under the title of "Recruitment to Established Posts in the Civil Service During the Reconstruction Period" (Stationery Office, 1944, Cmd. 6567, 4d.). This document deals almost entirely with the administrative, executive and clerical classes of the Civil Service, although the admission is made that the professional, scientific and technical classes are equally important. It is stated that the "departments employing these staffs are now engaged in formulating proposals for them which will, as far as possible, incorporate the principles recommended for the general classes . . . . It is expected that the matter will shortly be sufficiently advanced for discussion with Civil Service staff representatives to take place through the Whitley machinery". Since it is difficult to see how one of the major principles, that of reserving for ex-service personnel a large proportion of vacancies that arise in Government departments, can be applied to scientists, most of whom have been reserved during the war, it is to be hoped that the Government will not delay in following up this White Paper with another clarifying the prospects for professional, scientific and technical classes.

New Zealand Keeps in Touch

Two papers describing the way New Zealand maintains scientific liaison with Britain and other countries were delivered to the Royal Society of Arts in London recently. Dr. I. E. Coop dealt with the subject of specialised war-time co-operation, instancing the fact that it was with information obtained from the United Kingdom in the early years of the war that New Zealand was enabled to build a considerable number of radar sets of a type suited to its special needs as an isolated island country in the Pacific. In 1941 a scientific liaison officer was posted to London to establish an office for the collection of information about war-time development and its despatch to New Zealand. At the same time the scientific resources of New Zealand were mobilised, and development and production put in hand.

The major scientific development undertaken in New Zealand was in radar and to this end the Radio Development Laboratory was set up. This laboratory was responsible for the development of prototype radar and radio equipment and, because of the easier interchange between small organisations in a small country, personnel from the laboratory were able to assist in the manufacture of the equipment and in its subsequent operation against the enemy. At the four university colleges constituting the University of New Zealand, extra-mural development work was done in engineering, radio, optics, chemical warfare and other subjects, all of which was under the direction of the Department of Scientific and Industrial Research. A contribution was also made by New Zealand scientists in the fitting and repair of complex scientific equipment being installed or used by the Services. In the campaign in the Solomon Islands a considerable amount of equipment was used which had thus been developed and produced in New Zealand. The experience which had been gained in tropical warfare in the Pacific put New Zealand in a position to supply scientific information to the United Kingdom on operational conditions out in the Pacific. It is hoped that this information, together with more from Australia, will be of value in the design and operation of special equipment manufactured in this country for use in the Far East and in the Pacific.

The other paper, by Mr. A. L. Poole, was a valuable background study, giving as it did a clear picture of the emphasis New Zealand scientists have always placed upon the necessity of maintaining contact with scientists in other countries. Because New Zealand is a small and isolated country, said Mr. Poole, she has deemed it wise to build up more highly-specialised scientific co-operation in the form of scientific liaison services, this being done under the N.Z. Department of Scientific and Industrial Research. After a brief explanation of the character of New Zealand's D.S.I.R.—it was formed in 1927, taking as its model the British D.S.I.R., except in so far as it covers most agricultural research, which in Britain is the concern of the Agricultural Research Council—the lecturer gave an account of the growth of the London Scientific Liaison Office and somet examples of liaison service. The first overseas liaison office of New Zealand's D.S.I.R. was permanently established in London on the formation of the department. Others have since the war been set up in Australia and the U.S.A., the latter serving Canada as well.

These centres carry a very small staff and could not cope effectively with all branches of science. Of considerable importance, therefore, in scientific liaison are the visits, on special matters, of New Zealand scientists to this and other countries, and the visits of overseas scientists to New Zealand. The functions of the London Scientific Liaison Office of the Department are multifarious. The Department subscribes to certain scientific institutions in this country. These are the Imperial Agricultural Bureaux, the Food Investigation Board of the British Department of Scientific and Industrial Research, the Wool Industries Research Association, and the Leather Research Association. Among the first duties of the London Office is, therefore, representation on the Food Investigation Board, and the Council of the Imperial Agricultural Bureaux, and keeping in close touch with the activities of all the above bodies in so far as they affect the Dominion. In addition, the office acts especially as Imperial Agricultural Bureaux liaison office for New Zealand. During the war it has also had representation on a number of other committees of the Ministry of Supply, and bodies which are covering research of immediate war concern.

"In so far as much time of the office is taken up in answering direct enquiries from its own and other departments in New Zealand, it is necessary to have a first-hand knowledge of the scientific institutions, and, to some extent, scientific personnel in this country, so that information may be obtained readily," said Mr. Poole. "Not infrequently it is necessary to obtain more than one view on the same matter, and to endeavour to sum these up in a manner likely to give investigators at a distance a balanced account. Any remaining time is used in paying general visits to research institutions and acting generally as "scavengers" of information. The service is, however, not all one way as it is frequently possible to pass on results from the Dominion and put workers here in direct touch with Dominion workers. In all these diverse duties it is pleasing to be able to remark that great assistance is received by the highest degree of co-operation from British scientists and scientific institutions."

Specific examples of co-operation leading to the solution of particular practical problems were quoted by the lecturer. He referred to the frequent exchange of breeding material for grass-improvement research carried out in Britain and in the Dominion. One result of liaison on fruit production has been the introduction into New Zealand of stocks from East Malling Research Station. One of the most outstanding pieces of co-operation involving not only Britain and New Zealand, but also a number of other empire countries, was the work of collecting South American potato species and varieties. (See DISCOVERY, October 1944, p. 318). This collection and subsequent investigation on it was made possible by contributions from several empire countries. A New Zealand scientist from the agronomy division is at present working on this collection at Cambridge where it is housed.

LETTERS TO THE EDITOR

IT is now two years since DISCOVERY reappeared and during that time the editor has received many useful suggestions from readers. We have been able to adopt quite a number of them; others have had to go into cold storage until after the war. One request that has been made frequently is that we should give news and reviews of scientific films. Coupling this idea with the proposal that B.B.C. features dealing with scientific features should be mentioned, we have decided to devote a little attention to both scientific films and radio programmes on scientific subjects. A start is made in this issue and we hope to be able to continue the practice from time to time in the future.

The need for a correspondence column we have long recognised to be an acute one. It is our intention from now onwards to allow a little space for readers' letters. So that this space can be used to the best advantage, the editor asks readers to be as brief as possible. No hard-and-fast criterion is possible in this connection, but for the present it can be said that any letter over 400 words in length will stand relatively little prospect of finding its way into print. We are reluctant to impose such a limitation, which we shall relax as soon as the paper supply allows, but readers will appreciate that the editing of DISCOVERY is a never-ending struggle to accommodate a quart in a pint pot. The usefulness of our correspondence column will largely depend on how far our readers assist us in achieving this end. Letters asking for information will continue to be treated as at present and will be answered by correspondence. And may we remind readers that the editorial office is now in London—at 244, High Holborn, W.C.1.

Photographing the Sea Bottom

SINCE 1938 a group of American scientists under the direction of Dr. Maurice Ewing, associate professor of geophysics at Columbia University, have been experimenting with underwater photography at great depths. Some details of this work, which was done aboard the research vessel *Atlantis* of the Woods Hole Oceanographic Institution, were given by Dr. Ewing in a recent lecture to the American Optical Society. The first camera they used was enclosed in an aluminium case that was pressure-resistant to a depth of 3,000 fathoms—about three miles—and equipped with specially made incandescent bulbs and batteries. It was released overboard unattached to the ship, being designed to take a series of pictures on striking bottom. Iron ballast was attached by a block of salt which dissolved after a certain time, freeing the ballast and allowing the buoyed camera to rise to the surface, the whole operation taking about one hour and a half. This camera was lost on its third trial, before enough experience had been gained to take satisfactory pictures, although some pictures were obtained at 3,000 fathoms.

Next was tried an apparatus consisting of a pyrex glass test tube, five feet long and six inches wide, containing a modified Argus camera designed to take two pictures on each lowering—one 30 seconds after striking bottom and another 30 seconds later. It was constructed to go to depths of 1100 fathoms and furnished with a ballast-releasing system similar to that of the first camera. For depths less than 100 fathoms, a fishing line was attached to the camera to draw it back to the ship after it had reached the surface. By 1940, more than 100 successful pictures showing the ocean bottom and various forms of marine life had been taken with this camera, to depths of about 500 fathoms, and information was obtained as to the force and direction of ocean currents by lowering various measuring devices attached in the field of view of the camera. Samples of the ocean bottom were, in some cases, taken simultaneously with the pictures by a bottom sampler fixed to the instrument and timed to close with the taking of the second picture. This camera, too, was eventually lost; it was being tried at 500 fathoms when it was presumed to have collapsed under pressure. The techniques and instruments have been further developed and work in this field is continuing. Practical application of the method has already been made in biological studies of marine plants and animals, determination of the geological characteristics of the ocean bottom, measurement of the ocean current, and in the identification and salvage of wrecked ships.

Surveying Seaweed Beds

In a paper published in the *Journal of the Marine Biological Association* (1944, **26**, No. 1, p. 37). Dr. V. J. Chapman of Cambridge University states that for the purpose of mapping seaweed beds aerial photographs have "more than fulfilled expectations". He recommends that when taking photographs the plane should fly so that the sun is either behind or even better on the wing side opposite that to which the camera is attached. There should not be too much wind, because ripples and waves tend to break up the outlines of the beds and also there is more reflection of light from a broken sea than from a calm one. The altitudes for securing the best results range from 1500 to 2000 feet. Quite satisfactory results can however be obtained up to 4000 feet, though the degree of accuracy with which the beds can be plotted from aerial photographs decreases at altitudes above 2000 feet. Oblique photographs are best for detecting beds, though they take longer to plot. Dr. Chapman also describes the

use of echo-sounding apparatus; with the portable M.S. 12 type of equipment designed by Henry Hughes and Son it was found possible to detect the presence of banks of ribbon wrack on a calm day.

Science for the Citizen

AT present the percentage of the listening public that tunes into science features on the radio is small (writes W.E.D.). Science is not within a mile of reaching the popularity enjoyed by ITMA. How then can the present audience be expanded? There was a great deal of sense in the suggestion recently made by Major T. H. Hawkins in *Nature* that the material for scientific broadcasts could be collected by scientists but, unless it was intended to present that material as a straight lecture, then it should be re-dressed in a more attractive form by a script writer of the calibre of Louis MacNeice. Presumably it was some such approach that was adopted in preparing the script for the broadcast describing how the *Origin of Species* came to be written. According to *The Radio Times*, the material was supplied by James Fisher, and the programme was written and produced by Stephen Potter. Fisher evidently did his work of compilation conscientiously; all the highlights of Darwin's career, his character, his book and its reception were there. But something was lacking. The minutiae of Darwin's work came over, but the scientific outlook that scientists are always stressing as essential if the popular presentation of science is to give a fair picture did not. The mechanics of the writing of the *Origin of Species* were cleverly conveyed . . . "conversations with Mr. Norman, the copyist—sheets full of corrections in Darwin's very bad handwriting—gaps and pauses when Darwin was will—experiments with rather Heath Robinson apparatus," and so on. Yet the origins of the theory of natural selection were but sketchily indicated. This theory can scarcely be quoted as an example of "spontaneous generation", yet that was just the impression that the broadcast gave. It was as though Stephen Potter was a 20th century Pope declaring: God said "Let Darwin be" and there was light. True, Malthus was mentioned; so too was Lamarck, in a brief derogatory aside, which was the more unfair since Darwin adopted Lamarck's idea about use and disuse. The radio Charles Darwin was apparently quite unrelated to Erasmus Darwin, and seemed to have few contacts with other scientists—except Hooker, who was made to look like a stooge. (Perhaps the script writer had been reading J. G. Crowther's contemptuous and inaccurate remark about botanists in *American Men of Science*). Yet we were told that Darwin's theory had *evolved;* one might have expected that the programme would have attempted to show the theory in relation to earlier theories and bearing some sign of recapitulation. But no: listeners were led to believe that natural selection burst upon the world like a lightning flash that had no antecedents.

One feels that the script writer, provided with a rich selection of material by James Fisher, was not well enough up in the subject to do more than skim of what he thought to be the cream. (Probably script writing is one of those flotation drocesses in which the best material tends to fall to the bottom). Some of the cream seemed to have clotted into clichés.

It is well to have an accomplished script writer, provided he avoids the old hokum, the clichéd tricks of the trade which not infrequently renders a professional script less refreshing than a more amateur one. If scientists are to prepare material for B.B.C. producers they will have to take more interest in what the B.B.C. eventually does with it. Facts are not foundlings to be left on the doorstep of Broadcasting House to be rigged out in clothing borrowed from the Brains Trust or Radio Newsreel. There is every need for closer co-operation between the B.B.C. and scientists, and there is much experimenting to be done before this kind of radio feature gives regular satisfaction.

Quite a number of changes are necessary before that is likely to happen. One has only to read *The Radio Times* and *The Listener* to see that at least some members of the B.B.C. are openly antagonistic to science and the scientific method. It is a pity that more scientists do not answer some of the moralising that goes on in these journals about the philosophy of science. *The Listener* on December 14 for instance discussed the culpability of science for the perversion of science, and argued thus naively: *One favourite line of defence, which has almost become a dogma, is that science is "neutral"—it is our own choice what we use it for. But is it really being "neutral" to give a stick of dynamite to an aborigine or a bottle of opium pills to an infant?* If the B.B.C.'s organ of opinion thinks like that, one wonders what the general run of B.B.C. producers feel about the science which, Sir Alan Powell claims, they endeavour, to popularise.

Turning from radio to films, the London Scientific Film Society exhibited the following films at its performance on December 11: *Potato Blight* (Realist Film Unit for Ministry of Agriculture), *The New Crop* (Green Park Unit for Ministry of Information, Ministry of Supply and Forestry Commission), *Reflex Action of the Pupil* (made by R. B. Morris of Kodak Research Laboratories) and *In the Sands of Central Asia* (Soviet Film Agency, written and directed by A. Zguridi with the advice of Professor A. L. Brodsky and I. I. Kolesnikov). Mr. Morris's research film created a great deal of interest, and the Soviet film (of which a British version is being prepared) was well received, though the sequence at its end symbolic of the way Soviet science "transforms the Desert into a flowering garden" seemed somewhat irrelevant, and depressing in so far as a rich fauna appeared due for obliteration. The other films were adequate for their purpose.

Some time ago it seemed certain that a film about penicillin was to be made, but nothing further has been heard of the plan. Perhaps the news that two Russian films about mould bacteriostatics—one dealing with the antibiotic from *Aspergillus* and the other about Gramicidin S—are in course of preparation. A kind of Soviet film for which there is yet no British counterpart is the scientific newsreel called "Science and Technology" which serves to acquaint ordinary cinema audiences with the latest achievements of Soviet sciencs; each film deals with four subjects.

Bats

BATS are a group that naturalists have been inclined to neglect, probably because their nocturnal habits make observation difficult. The ignorance which exists particularly of the habits of these mammals is emphasised in an article entitled "The Distribution of Bats in Hampshire", which Brian Vesey-Fitzgerald has contributed to the proceedings of the Hampshire Field Club (Vol. 16, Part 1, p. 64). As an example of this ignorance he cites the fact that, although many people have seen young birds being taught to fly, no one has seen a young bat taught; it is possible bats fly by instinct. The paper contains descriptions of the Noctule, Leisler's Bat, the Serotine, the Pipistrelle, the Long-Eared Bat, Daubenton's Bat, Natterer's Bat, the Whiskered Bat, Bechstein's Bat, the Barbastelle, the Greater and Lesser Horseshoe Bats, all of which occur in Britain. Records of their distribution are vague and incomplete, and Mr. Vesey-Fitzgerald considers that this state of affairs will continue as long as the vast majority of our naturalists are content to lump all bats together. "It is high time in fact that we ceased regarding the data on distribution given by Barrett-Hamilton (containing information acquired in and prior to 1910) as final, and commenced to compile County lists of the Cheiroptera in the excellent and thorough manner of our County lists of birds", he comments.

The Egyptian Institute

AT the direction of the Ministry of Education in Cairo, an Egyptian Institute has been set up at 4 Chesterfield Gardens, Curzon Street, London, W.1. Its objects are similar to those of the Institutes established by the British Council in various cities. It aims to promote wider contacts with scientific, educational, and other bodies in different parts of Britain, and it is building up the nucleus of a specialised library (several thousand volumes have so far been collected), special attention being given to references which would otherwise be difficult to get in London libraries.

"Science for Peace" Conference

A CONFERENCE to discuss the use of science in the post-war world will be held at the Caxton Hall, London, on February 17 and 18. It is being organised by the Association of Scientific Workers in order to draw attention to the need for science to be used as fully in peace-time as it has been during the war. Further particulars may be obtained from the Association of Scientific Workers Hanover House, 73 High Holborn, London, W.C.1.

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